University of California
San Francisco

UCSF

Campus Planning

Lori Yamauchi
Assistant Vice Chancellor
654 Minnesota Street, 2nd Floor
Box 0286
San Francisco, CA 94143-0286
tel: 415/476-2911
fax: 415/476-9478

January 18, 2013

Re: Draft Environmental Impact Report for the UCSF Mount Sutro Management Project

This is the Draft Environmental Impact Report (Draft EIR) for the UCSF Mount Sutro Management Project, a proposal to implement a number of management activities in the UCSF Mount Sutro Open Space Reserve at UCSF's Parnassus Heights campus site. The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, conversion planting (removal of non-native trees and plants and conversion to native species) in select areas, and construction of new trails.

To obtain a paper copy or to view reference materials, email UCSF Environmental Coordinator Diane Wong at EIR@planning.ucsf.edu or call (415) 502-5952.

To give written feedback on the Draft EIR, please write Ms. Wong at UCSF Campus Planning, Box 0286, San Francisco, CA 94143-0286, or email her at EIR@planning.ucsf.edu. Please include your full name and address in written correspondence. **All comments must be submitted during the 45-day public review period from January 18, 2013 to March 4, 2013 at 5 p.m.**

Another option is to attend and speak at the public hearing regarding the Draft EIR to be held on Monday, February 25, 2013 at 7:00 p.m. at the UCSF Millberry Union Conference Center, 500 Parnassus Avenue, in the Golden Gate Room. The purpose of this hearing is to solicit public comments on the adequacy and accuracy of information presented in the Draft EIR.

Comments received at the public hearing or in writing will be responded to in a Comments and Responses document to be prepared subsequent to the close of the comment period. Please note that all public comments made in writing or in oral testimony at the public hearing will be part of the public record. After preparation of the Comments and Responses document, the EIR will be made final.

Thank you for your interest in this project.

Sincerely,
Diane Wong, Environmental Coordinator
UCSF Campus Planning
654 Minnesota Street
San Francisco, CA 94143-0286
(415) 502-5952
EIR@planning.ucsf.edu

DRAFT

# Environmental Impact Report
# UCSF Mount Sutro Management

State Clearinghouse No. 2010122041

University of California
San Francisco

UCSF

**Financial and Administrative Services**
Campus Planning

# UCSF MOUNT SUTRO MANAGEMENT

## DRAFT ENVIRONMENTAL IMPACT REPORT

| | |
|---|---|
| Draft EIR Publication Date: | January 18, 2013 |
| Draft EIR Public Review Period: | January 18, 2013 through March 4, 2013 |
| Draft EIR Public Hearing Date: | February 25, 2013 |

# TABLE OF CONTENTS

## ENVIRONMENTAL IMPACT REPORT
## UCSF MOUNT SUTRO MANAGEMENT


Page

**1. INTRODUCTION**

1.1 Purpose of this Document ..... 1-1
1.2 Summary of the Proposed Project ..... 1-2
1.3 Environmental Review Process ..... 1-2
1.4 Scope of this EIR ..... 1-4
1.5 Report Organization ..... 1-5

**2. SUMMARY**

2.1 Purpose ..... 2-1
2.2 Project Description ..... 2-1
2.3 Project Objectives ..... 2-9
2.4 Required Approvals ..... 2-10
2.5 Topics of Known Concern ..... 2-10
2.6 Impact Summary ..... 2-10
2.7 Alternatives to the Proposed Project ..... 2-11
2.8 Issues to be Resolved/Areas of Controversy ..... 2-11

**3. PROJECT DESCRIPTION**

3.1 Project Location and Surrounding Uses ..... 3-1
3.2 Condition of the Reserve ..... 3-5
3.3 Project Objectives ..... 3-6
3.4 Background ..... 3-7
3.5 Project Description ..... 3-10
3.6 Mitigation Measures Included in the Project ..... 3-18
3.7 Mitigation Monitoring ..... 3-19
3.8 Required Approvals ..... 3-20

**4. ENVIRONMENTAL SETTING, IMPACTS, AND MITIGATION**

4.0 Introduction ..... 4.0-1
4.1 Aesthetics ..... 4.1-1
4.2 Air Quality ..... 4.2-1
4.3 Biological Resources ..... 4.3-1
4.4 Cultural Resources ..... 4.4-1
4.5 Geology and Soils ..... 4.5-1
4.6 Greenhouse Gas Emissions ..... 4.6-1
4.7 Hazards – Fire Hazards ..... 4.7-1
4.8 Hazards – Herbicide Use ..... 4.8-1
4.9 Hydrology ..... 4.9-1
4.10 Noise ..... 4.10-1

4.11 Wind ..... 4.11-1

**5. CEQA STATUTORY SECTIONS**

5.1 Significant and Unavoidable Environmental Impacts ..... 5-1
5.2 Significant Irreversible Changes ..... 5-1
5.3 Growth-Inducing Impacts ..... 5-2
5.4 Effects Found Not to Be Significant ..... 5-3
5.5

**6. ALTERNATIVES**

6.1 Alternatives to the Project ..... 6-1

**7. REPORT PREPARATION**

7.1 Report Authors ..... 7-1

**APPENDICES**

A. Initial Study and Initial Study/EIR Scoping Comment Letters
B. Air Emissions Estimates
C. Biological Resources Report
D. Cultural Resources Report
E. Geological Assessment
F. Greenhouse Gas Emissions Calculations
G. Herbicide Risk Assessment
H. Hydrology Calculations
I. Noise Assessment
J. Wind Data

**LIST OF FIGURES**

3-1 UCSF Campus Sites ..... 3-2
3-2 UCSF Mount Sutro Open Space Reserve ..... 3-3
3-3 UCSF Mount Sutro and Environs ..... 3-4
3-4 2001 Management Plan 10-year Management Actions ..... 3-8
3-5 Proposed Project Demonstration Areas ..... 3-11
3-6 Existing and Proposed Trails ..... 3-17
4.1-1 Aerial View Looking South ..... 4.1-2
4.1-2 Looking South From Lincoln Avenue/MLK Jr. Drive ..... 4.1-3
4.1-3 Looking South From Lincoln/3rd Avenues ..... 4.1-4
4.1-4 Looking East from Grand View Park ..... 4.1-4
4.1-5 Looking East from Kirkham Street/7th Avenue ..... 4.1-5
4.1-6 Looking East from Lawton Street/8th Avenue ..... 4.1-5
4.1-7 Looking West from 17th/Clayton Streets ..... 4.1-6
4.1-8 Looking West from 17th/Shrader Streets ..... 4.1-6
4.1-9 Looking Southwest from Stanyan/Rivoli Streets ..... 4.1-7
4.1-10 Looking South from Willard Street ..... 4.1-7
4.1-11 Looking South from Edgewood Avenue ..... 4.1-8
4.1-12 Looking Northeast from Olympia Way/Clarendon Avenue ..... 4.1-8
4.1-13 Looking North from Clarendon Avenue/Oak Park Drive ..... 4.1-9
4.1-14 Limited Views along Trails ..... 4.1-10
4.1-15 Limited Views along Trails ..... 4.1-10
4.1-16 The Summit ..... 4.1-11

4.1-17 Highway 1 "13 Curves" Project ..... 4.1-15
4.1-18 Camino Del Canyon Project ..... 4.1-16
4.4-1 Langley's 1890 Guide Map to the City of San Francisco ..... 4.4-12
4.4-2 1935 Aerial View of Mount Sutro showing extent of logging ..... 4.4-14
4.4-3 View of Affiliated Colleges and Mount Sutro, circa 1910 ..... 4.4-17
4.4-4 View of Mount Sutro from Stanyan Street, circa 1910 ..... 4.4-18
4.4-5 Existing and Proposed Trails ..... 4.4-23
4.7-1 West Side of the Reserve Looking West ..... 4.7-3
4.7-2 West Side of the Reserve Looking Northwest ..... 4.7-3
4.7-3 Sparse Tree Canopies ..... 4.7-4
4.8-1 Proposed Demonstration Project Areas ..... 4.8-3
4.8-2 Mount Sutro Watershed Map ..... 4.8-5
4.9-1 San Francisco Regional Sewer System Map ..... 4.9-2
4.9-2 Mount Sutro Watershed Map ..... 4.9-4
4.10-1 Common Noise Levels ..... 4.10-2
4.11-1 San Francisco NOAA Buoy Wind Rose 2007-2009, 2011 ..... 4.11-4
4.11-2 Wind Station Locations ..... 4.11-10

**LIST OF TABLES**

2.0-1 Summary of Impacts and Mitigation Measures ..... 2.0-13
2.0-2 Summary Comparison of Project Alternatives ..... 2.0-27
4.2-1 National and State Air Quality Standards ..... 4.2-3
4.2-2 CEQA Significance Thresholds - BAAQMD ..... 4.2-5
4.2-3 Estimated Construction Emissions – URBEMIS 2007 ..... 4.2-8
4.2-4 Estimated Operational Emissions ..... 4.2-9
4.3-1 Special-Status Species Potentially Occurring in the Vicinity of the Mount Sutro Open Space Reserve ..... 4.3-9
4.6-1 Top Five GHG Producer Countries and the European Union ..... 4.6-4
4.6-2 AB 32 Scoping Plan Measures ..... 4.6-9
4.6-3 Estimated GHG Emissions During Vegetation Removal Activities ..... 4.6-23
4.8-1 Project Herbicide Treatment Schedule ..... 4.8-10
4.8-2 Humans – Comparison of Herbicide Risks for Selected Exposure Scenarios ..... 4.8-15
4.8-3 Terrestrial Wildlife – Comparison of Herbicide Risks for Selected Exposure Scenarios ..... 4.8-16
4.8-4 Aquatic Wildlife – Comparison of Herbicide Risks for Selected Exposure Scenarios ..... 4.8-18
4.9-1 Summary of HEC-HMS Model Simulations for Project Watersheds for Pre-Project and Post-Project Watershed Conditions: 5-Yr, 24-Hr. Storm ..... 4.9-15
4.9-2 MUSLE Watershed Sediment Yields for the 5-Yr, 24-Hr. Design Rainstorm ..... 4.9-17
4.11-1 San Francisco Mission Dolores Monthly Climate Summary ..... 4.11-2
4.11-2 San Francisco Airport Wind Information ..... 4.11-3
4.11-3 Number of Days in Year Wind Gusts Equaled or Exceeded 22.4 m/s (50mph) ..... 4.11-5
4.11-4 Wind Data Summary by Station ..... 4.11-11
4.11-5 Station Wind Analysis by Time Correlation ..... 4.11-13

# CHAPTER 1

# INTRODUCTION

## 1.1 PURPOSE OF THIS DOCUMENT

This Draft Environmental Impact Report (EIR) has been prepared in accordance with the California Environmental Quality Act, Public Resources Code Sections 21000, et seq. ("CEQA") to provide an assessment of the potentially significant environmental effects of the proposed Mount Sutro Management project (hereinafter the proposed project). As required by CEQA, this Draft EIR (1) assesses the potentially significant environmental effects of the proposed project, including cumulative impacts of the proposed project in conjunction with past, present, and reasonably foreseeable future development; (2) identifies feasible means of avoiding or substantially lessening significant adverse impacts; and (3) evaluates a range of reasonable alternatives to the proposed project, including the No Project alternative. The University of California (the University) is the "lead agency" for the project evaluated in this Draft EIR. The Board of Regents of the University of California (The Regents) or its delegated committee or administrative official, has the principal responsibility for approving this project.

The University of California, San Francisco (UCSF) has prepared this EIR on the proposed project for the following purposes:

- To inform the general public, the local community, and public agencies of the nature of the proposed project, its potentially significant environmental effects, feasible measures to mitigate those effects, and its reasonable and feasible alternatives;

- To enable the University to consider the environmental consequences of approving the proposed project; and

- To satisfy CEQA requirements.

As described in CEQA and the *State CEQA Guidelines*, public agencies are charged with the duty to avoid or substantially lessen significant environmental effects of proposed projects, where feasible. In discharging this duty, a public agency has an obligation to balance the proposed project's significant effects on the environment with its benefits, including economic, social, technological, legal, and other benefits. This EIR is an informational document, the purpose of which is to: identify the potentially significant effects of the proposed project on the environment; identify mitigation measures that would avoid or reduce those significant effects; identify any significant and unavoidable adverse impacts that cannot be mitigated to a less-than-significant level; and identify reasonable and feasible alternatives to the proposed project that

would eliminate any significant adverse environmental effects or reduce the impacts to a less-than-significant level.

The lead agency is required to consider the information in the EIR, along with any other relevant information, in making its decision on the proposed project. Although the EIR does not determine the ultimate decision that will be made regarding implementation of the proposed project, CEQA requires the University to consider the information in the EIR and make findings regarding each significant effect identified in the EIR before it can approve the proposed project. The Regents or its delegated committee or administrative official would certify the Final EIR prior to taking any action approving the proposed project.

## 1.2 SUMMARY OF THE PROPOSED PROJECT

UCSF proposes to implement a number of management activities in the UCSF Mount Sutro Open Space Reserve ("Reserve") at its flagship campus site at Parnassus Heights. Proposed management activities include forest-thinning and removal of understory vegetation to reduce the risk of a wildfire and to improve forest health; native plant restoration and enhancement; conversion planting (removal of non-native trees and plants and conversion to native species); and the creation of new trails.

## 1.3 ENVIRONMENTAL REVIEW PROCESS

UCSF has filed a Notice of Completion (NOC) with the Governor's Office of Planning and Research, State Clearinghouse indicating that this Draft EIR has been completed and is available for review and comment by agencies and the public.

This Draft EIR has been made available for review by agencies, organizations, the public and interested parties for a public review period of 45 days, as mandated by California law. In reviewing the Draft EIR, reviewers should focus on the document's adequacy in identifying and analyzing significant effects on the environment and ways in which the significant effects of the proposed project might be avoided or mitigated. To ensure inclusion in the Final EIR and full consideration by the lead agency, comments on the Draft EIR must be received during the public review period at the following address:

UCSF Campus Planning
654 Minnesota Street
San Francisco, California 94143-0286
Contact: Diane Wong, Senior Planner
EIR@planning.ucsf.edu

UCSF will accept e-mail comments in lieu of traditional mailed comments. Following the close of the review period, responses to comments on the Draft EIR will be prepared and published as a separate document. The Draft EIR text and appendices, together with responses to comments and any text changes made to the Draft EIR will constitute the Final EIR.

The Regents, the decision-making body for the University, or its delegated committee or administrative official (collectively "The Regents") will review UCSF's Mount Sutro Management Final EIR for adequacy and consider it for certification pursuant to the requirements of Section 15090 of the *State CEQA Guidelines*. If The Regents certifies the Final EIR, then The Regents will consider the project separately for approval or denial. If The Regents chooses to approve the project, findings on the feasibility of reducing or avoiding significant environmental effects will be made and, if necessary, a Statement of Overriding Considerations will be prepared. If The Regents approves the project, a Notice of Determination (NOD) will be prepared and will be filed with the State Clearinghouse. The NOD will include a description of the project, the date of approval, an indication of whether Findings were prepared and a Statement of Overriding Considerations was adopted, and the address where the Final EIR and record of project approval are available for review.

### 1.3.1 TYPE OF EIR

This is a project EIR prepared pursuant to Section 15161 of the *State CEQA Guidelines*. Because the proposed project is proposed by the University, relevant mitigation measures adopted by The Regents in conjunction with the approval of the 1996 Long Range Development Plan ("LRDP"), 2005 LRDP Amendment #2 – Hospital Replacement project, and 2008 Medical Center at Mission Bay project are included in and made a part of the proposed project. These mitigation measures are listed in the Project Description and identified in each resource subsection of **Section 4.0**. The analysis presented in **Section 4.0** evaluates environmental impacts that would result from project implementation following the application of these mitigation measures, as part of the project as proposed. The mitigation measures that are included in the project would be monitored pursuant to the Mitigation Monitoring and Reporting Plan that will be adopted by The Regents for the proposed project.

### 1.3.2 PUBLIC AND AGENCY REVIEW

On December 10, 2010, a Notice of Preparation (NOP), including an Initial Study, was published for the Mount Sutro Management EIR. The 30-day comment period ended on January 18, 2011. A

copy of the NOP/Initial Study is included in Appendix A. Several written comments were received on the NOP, which are also included in Appendix A.

An EIR scoping meeting was held at Millberry Union at the Parnassus Heights campus site on January 10, 2011. The purpose of this meeting was to inform the public and interested agencies of the proposed project, solicit comments, and identify areas of concern. Comments received from the public are summarized under each environmental section in this EIR. The proposed project analyzed in this EIR is substantially the same as the project identified in the NOP.

Copies of this Draft EIR and relevant materials referenced therein are available for review online at http://campusplanning.ucsf.edu/ and at the following locations:

UCSF Kalmanovitz Library, 530 Parnassus Avenue

San Francisco Public Library - Sunset Branch, 1305 18th Avenue and Park Branch, 1833 Page Street.

### 1.3.3 INTENDED USES OF THIS EIR

The Regents will use this EIR to evaluate the environmental implications of approving the proposed project. There are no responsible agencies with permitting authority over the project, as the proposed project does not require any discretionary approvals from other agencies.

## 1.4 SCOPE OF THIS EIR

UCSF completed a preliminary review of the project, as described in Section 15060 of the *State CEQA Guidelines*, and determined that environmental review was required. UCSF prepared an Initial Study in December 2010 and determined that an EIR would be prepared. Based on the Initial Study and the comments received at the scoping meeting and in response to the NOP, it was determined that the EIR would evaluate the following environmental topics in further detail:

- Aesthetics
- Air Quality
- Biological Resources
- Cultural Resources
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards & Hazardous Materials
- Hydrology/Water Quality
- Noise
- Wind

## 1.5 REPORT ORGANIZATION

This Draft EIR is organized into the following sections:

**Section 1.0 - Introduction**: provides an introduction and overview describing the purpose and scope of topics addressed in this EIR and the environmental review process.

**Section 2.0 - Executive Summary**: summarizes environmental consequences that would result from the proposed project, provides a summary table that denotes anticipated significant environmental impacts, describes identified mitigation measures, and indicates the level of significance of impacts before and after mitigation.

**Section 3.0 - Project Description**: describes the proposed project.

**Section 4.0 - Environmental Setting, Impacts, and Mitigation Measures**: describes the environmental setting, including applicable plans and policies; provides an analysis of the potential environmental impacts of the proposed project; and identifies mitigation measures to avoid or reduce significant impacts. It also includes an evaluation of the project's cumulative impacts.

**Section 5.0 - Alternatives**: summarizes alternatives to the proposed project and the comparative environmental consequences of each alternative. This section includes an analysis of the No Project Alternative, among others, as required by CEQA.

**Section 6.0 - Other CEQA Considerations**: provides a discussion of the proposed project's significant and unavoidable impacts, significant irreversible changes which would be caused if the proposed project were to be implemented, the potential for growth inducement from the proposed project, and a brief description of the environmental effects that were found not to be significant and, therefore, not evaluated in further detail.

**Section 7.0 - Report Preparation**: provides a list of the individuals involved in the preparation of this EIR.

# CHAPTER 2

# EXECUTIVE SUMMARY

## 2.1 PURPOSE

This Draft Environmental Impact Report (EIR) has been prepared in accordance with the California Environmental Quality Act, Public Resources Code Sections 21000, et seq. ("CEQA") to provide an assessment of the potentially significant environmental effects of the proposed Mount Sutro Management project (hereinafter the proposed project). It is the intent of this Executive Summary to provide the decision-makers and the public with a clear, simple, and concise description of the proposed project and its potential significant environmental impacts. Section 15123 of the *California Environmental Quality Act (CEQA) Guidelines* requires that the summary identify each significant effect, recommended mitigation measure(s), and alternatives that would minimize or avoid potential significant impacts. The summary is also required to identify areas of controversy known to the lead agency, including issues raised by agencies and the public and issues to be resolved. These issues include the choice among alternatives and whether or how to mitigate significant effects. This section focuses on the major areas of importance in the environmental analysis for the proposed project and utilizes non-technical language to promote understanding.

## 2.2 PROJECT DESCRIPTION

The University of California, San Francisco (UCSF) proposes to implement a number of management activities in the UCSF Mount Sutro Open Space Reserve ("Reserve") at its flagship campus site at Parnassus Heights. The University-owned Reserve is a largely undeveloped 61-acre forest located within the Parnassus Heights campus site near the geographical center of San Francisco. The Reserve is surrounded by the UCSF campus -- UCSF's hospital, research, educational and support structures to the north/northwest -- and by urban residential neighborhoods to the south, east and west. In addition, the Interior Greenbelt natural area, owned by the City and County of San Francisco, is adjacent to the east side of Reserve.

The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and plants and conversion to native species). Vegetation management actions are proposed to occur throughout the Reserve over many years. Under full or worst-case implementation of management activities under the proposed project, approximately 60% of all the existing trees, including large and small trees, could be removed from the Reserve, the majority of which would be small trees less than 12 inches in diameter.

Implementation would be phased beginning with four demonstration projects that were crafted with the interested public in the community process described below.

The first three demonstration projects are planned for implementation following the completion of environmental review and project approval. The fourth demonstration project would be implemented approximately one year after the first three demonstration projects to incorporate lessons learned from the first three demonstration projects. Also, the proposed project would include a "Hands-Off" management area at the request of some community members. In the Hands-Off management area, no vegetation management would be undertaken for the one-year duration of the first three demonstration projects.

The demonstration projects would include a range of potential management actions that could be implemented later throughout the entire Reserve. Such actions would be first implemented in these four small areas to "demonstrate" to the public the range of potential results. Public feedback would then inform the University's choices in the management activities to be applied to the remainder of the Reserve over time. The management actions identified for the demonstration areas are proposed to be applied ultimately beyond the demonstration areas to the remainder of the Reserve, as appropriate, subject to further refinement by UCSF in consultation with the interested public. Accordingly, this EIR conservatively analyzes environmental impacts resulting from the full range of management activities proposed for the entire 61-acre Reserve.

Several principles will govern the implementation of management activities, including:

- Adaptive Management: UCSF is committed to the principle of adaptive management as defined in the 2001 Plan, allowing for public input and opinion and adjustment of management activities before application to other areas of the Reserve.[1]
- Limited Use of Herbicides: Where herbicide use is indicated, targeted spot-application methods would be employed on tree stumps, vine, blackberry and broom stems, and on poison oak adjacent to trails.
- Tree Spacing: Where tree removal is indicated, the priority for removal is dead, dying, unhealthy, and hazardous trees. Where trees must be removed to achieve desired spacing, the next priority would be removal of trees smaller than 12 inches in diameter, followed by removal of trees larger than 12 inches in diameter.

[1] Adaptive management is a flexible, learning-based management approach that allows for changes in response to a problem or issue based on new information. Decision-making incorporates monitoring of a situation, learning, and modifying actions if necessary in order improve long-term management outcomes.

## 2.2.1 DEMONSTRATION PROJECTS

### 2.2.1.1 #1. SOUTH RIDGE AREA – 3 ACRES

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 30 feet between trunks
- Tree stump treatment: 1 acre – rely on hand maintenance; 1 acre –cover with tarps; 1 acre – apply herbicides
- Sprout control: cut mechanically or use goat grazing 1-2 times per year for 3-5 years in 1 acre where stumps are not tarped or treated with herbicide

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak); islands of brush will be maintained for wildlife
- Spot-treat cut tree vines, blackberry stems and poison oak adjacent to trails with herbicide in 1 acre
- Mow, use goat grazing and/or use herbicides consistent with city standards, annually or every other year for 5 years, depending on rate of re-growth

### 2.2.1.2 #2. EDGEWOOD AVENUE AREA – 2 ACRES

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning minimal, mostly acacias. Of those areas to be thinned, remaining trees to average spacing of about 30 feet between trunks, close to the spacing that currently exists in most of this area
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Initially, mow up to 90-100% (excluding native plants)
- Mow and/or use goat grazing annually or every other year for 5 years, depending on rate of re-growth

### 2.2.1.3 #3: NORTH SIDE OF SUMMIT – <0.5 ACRE

Trees

- Remove trees minimally, only as needed to prevent shading of existing Nootka reed grass area
- Remove trees minimally, only as needed to maintain a clear view corridor to the northeast
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Hand-remove non-native plants from grass area

### 2.2.1.4 #4. EAST BOWL CORRIDOR – 2 ACRES

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 60 feet between trunks
- Tree stump treatment and sprout control would depend on outcome of Demonstration Project 1, but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used
- Planting of native shrubs and trees (1 acre irrigated, 1 acre non-irrigated)

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak along trails); large areas of underbrush are expected to be maintained in this demonstration area
- Re-growth control depends on outcome of Demonstration Project 1 but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used (herbicides would not be used if it can be demonstrated in Demonstration Project 1 that undesirable understory plants can be controlled at a reasonable cost without herbicides.)

### 2.2.1.5 "HANDS- OFF" MANAGEMENT AREA: SOUTH RIDGE AREA – 2 ACRES

Trees

- No changes to existing trees, except that maintenance will be performed to remove and prune hazardous trees near homes and trails for the safety of residents and visitors and to keep trails clear (including trash pick-up).

Understory

- Understory would remain as is
- Trails would be kept clear, including trash removal

## 2.2.2 CONTINUED IMPLEMENTATION

Following the completion and assessment of the Demonstration projects, targeted management actions would potentially be applied to the remainder of the Reserve. For purposes of this EIR, it is assumed that all lands would be subject to the proposed vegetation management actions noted in this Project Description, which include the following:

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 30 feet between trunks, except in Demonstration Area #4, East Bowl Corridor, where average trunk spacing would be roughly 60 feet to accommodate plantings of redwood, willow, and bay trees and native forbs and shrubs.
- In some select areas along trails and at the summit, trees would be removed to create views.
- Steep slopes that are inaccessible by heavy equipment (about 15 acres) would not be thinned.
- The large scale thinning work would be phased – no more than a quarter of the Reserve would be thinned at any given time.
- Tree stump treatment and sprout control would depend on the outcome of the Demonstration Projects, and could include techniques such as covering with tarps, sprout cutting, or goat grazing. For purposes of a conservative EIR analysis, it is assumed, as a worst-case scenario, that herbicides will be used.
- Selective planting of native shrubs and trees.

Regarding the select planting of native shrubs and trees, the 2001 Management Plan discussed conversion planting locations on the summit, in the East Bowl Corridor (Demonstration Area #4), and in the South Ridge Area (including in Demonstration Area #1). As discussed, the summit has been planted with a native plant garden. Conversion planting in the East Bowl Corridor would be completed as part of Demonstration Project #4). The 2001 Management Plan identified for the South Ridge area the planting of Monterey cypress to create a windbreak ("Area J" in the 2001 Management Plan), and the planting of Oak Woodland ("Area K"). The Monterey cypress windbreak is no longer proposed. In the future, Oak Woodland may be planted in Area K, an area of roughly 1.5 acres, should funding become available.

Of the Reserve's 61 acres, conversion planting would occur in the East Bowl Corridor (about 2 acres) and potentially in Area "K" (about 1.5 acres). The summit (about 1.5 acres) predominantly contains native plants. Therefore, about 56 acres of forested area would remain where the predominant species is eucalyptus. Thus, the overwhelming majority of the Reserve would remain a eucalyptus forest, although at a lower density of trees per acre than exists today.

Understory

- Initially, mechanically remove (via mowing, cutting) up to about 90% of the non-native biomass, including poison oak along trails. Large areas of underbrush are expected to be maintained, and steeper slopes (>40 percent) may not be cut at all.
- Re-growth control may be conducted using various techniques including mowing, goat grazing, and/or herbicides, which would be applied annually or every other year for 5 years, depending on the rate of re-growth.

### 2.2.3 TRAILS

Over the past several years, trails have been restored and enhanced to improve access throughout the Reserve for the enjoyment of visitors. For example, an historic trail that was only recently discovered was restored by the Mount Sutro Stewards. Three new trails are proposed as part of the project: (1) a trail on the north side of the Reserve connecting the Historic Trail to the campus, allowing for ease of access to/from the campus; (2) a trail connecting the South Ridge and Quarry Road Trails to Christopher Drive, allowing for easier public access from the south side of the Reserve; and (3) an extension of this new trail to Clarendon Avenue and to trails to the Interior Greenbelt (on City-owned land) and southeast of the Reserve. Proposed trail alignments are approximate and have not yet been designed. The creation of these new trails will require minimal vegetation removal, minor amounts of grading and new trail markers.

### 2.2.4 ONGOING MAINTENANCE

The University, with the assistance of the UCSF Mount Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees, and restoring trails. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

### 2.2.5 BEST MANAGEMENT PRACTICES

The following best management practices (BMPs) are incorporated into the proposed project:

1. Disturbance to existing grades and vegetation will be limited to the actual treatment or restoration areas and necessary access routes. Placement of all trails, staging areas and other facilities will avoid and limit disturbance to existing native plants to the maximum extent practicable, with the exception of poison oak. Where possible,

existing ingress or egress points will be used and contours of the work area will be returned to pre-construction conditions.

2. Disturbed soils resulting from treatment activities will be stabilized prior to the rainy season by spreading woodchips or shreds or other mulch materials over the bare ground.
3. Straw wattles, silt fencing, straw bales, or similar sediment control measures will be installed on contours along the lower edge of the treatment areas to prevent excess sediment from entering the watershed, if deemed necessary.
4. To avoid attracting predators, food-related trash will be disposed in closed containers and regularly removed from the work areas.
5. All construction material, wastes, debris, sediments, rubbish, vegetation, trash, fencing, etc., will be removed from the site upon completion of treatments and transported to an authorized disposal area, as appropriate, and per all federal, State and local laws and regulation.
6. All construction-related holes will be covered to prevent entrapment of native amphibians, reptiles and small mammals.

## 2.2.6 MITIGATION MEASURES INCLUDED IN THE PROJECT

The following LRDP mitigation measures are included in and made part of the proposed project.

*Mitigation Measure #1: Archaeological Resources:* [modified from LRDP Amendment #2 Hospital Replacement EIR Mitigation Measure 4.3-1, and modified (as shown in underline) from the Initial Study for the UCSF Mount Sutro Management project] Grading and soil disturbance associated with the proposed project could cause substantial adverse changes to archaeological resources at the project site. Should an archaeological artifact be discovered at the site during ground disturbance activities, pursuant to CEQA Guidelines 15064.5(f), "provisions for historical or unique archaeological resources accidentally discovered during construction" should be instituted. In the event that any prehistoric or historic subsurface cultural resources are discovered during ground disturbing activities, all work within 100 feet of the resources shall be halted and UCSF shall consult a qualified archaeologist/paleontologist to assess the significance of the find (per Public Resources Code Section 5024.1, Title 14 California Code of Regulations, Section 4852 and/or Public Resources Code 21083.2 in the event of a unique archaeological find). If any find is determined to be significant and will be adversely affected by the project, representatives of UCSF and the qualified archaeologist/paleontologist would meet to determine the appropriate avoidance measures or other appropriate mitigation (per CEQA Guidelines 15064.5(b) and Public Resources Code 21083.2). All significant cultural materials recovered shall be subject to scientific analysis, professional museum curation, and documented by the qualified professional according to current professional standards (per the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44716)). If the discovery includes human remains, CEQA Guidelines 15064.5 (e)(1) shall be followed. In the event of the accidental discovery or recognition of any human remains in any location other than

a dedicated cemetery, steps to be taken include:

> (1) There shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until:
>
> (A) The coroner of the county in which the remains are discovered must be contacted to determine that no investigation of the cause of death is required, and
>
> (B) If the coroner determines the remains to be Native American: i) The coroner shall contact the Native American Heritage Commission within 24 hours. ii) The Native American Heritage Commission shall identify the person or persons it believes to be the most likely descended from the deceased Native American. iii) The most likely descendent may make recommendations to the landowner or the person responsible for the excavation work, for means of treating or disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in Public Resources Code Section 5097.98, or
>
> (2) Where the following conditions occur, the landowner or his authorized representative shall rebury the Native American human remains and associated grave goods with appropriate dignity on the property in a location not subject to further subsurface disturbance.
>
> (A) The Native American Heritage Commission is unable to identify a most likely descendent or the most likely descendent failed to make a recommendation within 24 hours after being notified by the commission.
>
> (B) The descendant identified fails to make a recommendation; or
>
> (C) The landowner or his authorized representative rejects the recommendation of the descendant, and the mediation by the Native American Heritage Commission fails to provide measures acceptable to the landowner.

*Mitigation Measure #2: Construction Noise:* [from the UCSF Medical Center at Mission Bay EIR, Mitigation Measure MCMB.5-1, and modified (as shown in underline from the Initial Study for the UCSF Mount Sutro Management project] Use of heavy equipment for management activities would, on a temporary basis, elevate noise levels in and around the project site, and particularly at nearby sensitive receptors. UCSF shall require contractors to minimize construction noise impacts by use of proper equipment and work scheduling. Construction hours shall be limited to the following schedule:

- Monday through Friday, 7 a.m. to 5 p.m. for not noisy work (80 decibels or less at 100 feet)
- Monday through Friday, 8 a.m. to 5 p.m. for noisy work (more than 80 decibels at 100 feet)

- Extended hours only with 24-hour advanced notice from the UCSF project manager (Monday through Friday, 5 p.m. to 8 p.m.; Saturday 7 a.m. to 8 p.m.; and Sunday 8 a.m. to 4:30 p.m.)

- No noisy work on Saturdays and Sundays.

- Designate a UCSF community contact person to receive and resolve construction complaints.

## 2.3 PROJECT OBJECTIVES

Section 15124(b) of the *State CEQA Guidelines* requires that the project description in an EIR include "a statement of the objectives sought by the applicant," which should include "the underlying purpose of the project." The primary objectives of the proposed management actions fall into four broad categories:

- to improve safety for the people and property in the environs of the Reserve
- to enhance the overall health of the Reserve
- to improve the aesthetics of the Reserve
- to increase the usability of the Reserve

The specific objectives of the proposed project, as described in the *UCSF Mount Sutro Open Space Reserve Community Planning Process Summary Report*, November 2010, are:

Safety

- To reduce fuel load and potential for wildfires
- To provide emergency response access
- To remove hazardous trees near trails, roads and structures
- To improve trailside visibility
- To facilitate long-term maintenance

Health

- To reduce competition among trees (increase growing space, soil/plant moisture and fertility)
- To remove diseased and unhealthy trees
- To create a variety of tree ages
- To increase tree species diversity
- To remove vines from tree trunks
- To monitor and sustain the health of the forest

Aesthetics

- To maintain a forested setting
- To maintain attractive healthy trees
- To improve visibility within the forest
- To enhance view corridors from the Reserve

Usability

- To maintain adequate path and trailside clearance
- To place logs for seating along trails and to close unauthorized trails
- To modify steep trail segments with switchbacks
- To enrich habitat and enhance the outdoor experience of the Reserve's users

## 2.4 REQUIRED APPROVALS

Action by The Regents (including any Regents-delegated committee or official): Upon certification of the EIR, The Regents or its designee will consider whether to approve the proposed management actions.

Action by Other Agencies: There are no responsible agencies that have approval authority over the proposed project. Trustee agencies include the California Department of Fish and Game.

## 2.5 TOPICS OF KNOWN CONCERN

To determine which environmental topics should be addressed in the this EIR, UCSF prepared an Initial Study and circulated it along with a Notice of Preparation (NOP) in order to receive input from interested public agencies and private parties. Copies of the NOP and Initial Study are presented in **Appendix A** of this EIR. Based on both the Initial Study and the NOP comments, this EIR addresses the following environmental topics in depth:

- Aesthetics
- Air Quality
- Biological Resources
- Cultural Resources
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards – Fire Hazards
- Hazards – Herbicide Use
- Hydrology
- Noise
- Wind

## 2.6 IMPACT SUMMARY

A detailed discussion regarding potential impacts is provided Section 4.0, Environmental Setting, Impacts, and Mitigation Measures. In accordance with the *State CEQA Guidelines*, a summary of the project's impacts is provided in Table 2.0-1, Summary of Impacts and Mitigation Measures, presented at the end of this section. The proposed project would have significant and unavoidable impact with regard to increased noise exposure to adjacent residents in the

Edgewood area. All other project-level impacts of the proposed project would either be less than significant or would be reduced to a less than significant level with the proposed project-level mitigation measures. All cumulative impacts would also be less than significant.

## 2.7 ALTERNATIVES TO THE PROPOSED PROJECT

Project alternatives include the following:

**No Project Alternative.** This alternative assumes the proposed project would not be implemented. However, ongoing maintenance in the Reserve, an activity exempt from environmental review under CEQA, would continue as it did prior to the project being proposed.

**Reduced Project Alternative.** This alternative assumes forest-thinning and understory removal activities would be scaled back to roughly half the amount desired by UCSF (i.e. tree-spacing at roughly 15 feet on average between tree trunks instead of 30 feet, and understory removal of about 45% instead of 90%). Select tree and vegetation removals to create views from the Reserve would be included in this Alternative. Trails would be constructed as with the proposed project. In addition, herbicide use is assumed to occur as with the proposed project. However, no management activities would occur within the area adjacent to the Edgewood Avenue properties.

An alternative that involved no herbicide use was considered but was determined to be unnecessary to study in this EIR. The University has not yet determined whether herbicides would be used in the Reserve as part of proposed project, other than as prescribed in the Demonstration Projects, and the University has the option to forgo herbicide use if it finds that alternative regrowth control methods are effective. Further, an analysis of the environmental consequences of not using herbicides would greatly depend on the effectiveness of the alternative methods to herbicides. Given that the Demonstration Projects are designed in part to test the effectiveness of herbicide use against alternative regrowth control methods, an EIR alternative that involves no herbicide use would not provide any additional useful information for decision makers or practical information for those who would participate in project implementation.

Detailed descriptions of the two alternatives evaluated in detail and their comparative merits are presented in **Section 6.0** of this EIR. Table 2.0-2, Summary Comparison of Project Alternatives, which follows Table 2.0-1, presents a comparison of the environmental impacts of each alternative to those that are expected to result from the proposed project.

Based on the analysis presented in the EIR, the Reduced Project Alternative was identified as the Environmentally Superior Alternative (see **Section 6.0** of this EIR).

## 2.8 ISSUES TO BE RESOLVED AND AREAS OF CONTROVERSY

This EIR addresses environmental issues associated with the proposed project that are known to the lead agency or were raised by other public agencies or interested parties during the EIR

scoping process. An EIR scoping meeting was held at Millberry Union at the Parnassus Heights campus site on January 10, 2011. The purpose of this meeting was to inform the public and interested agencies of the proposed project, solicit comments, and identify areas of concern. Comments from the public included concerns about impacts on the aesthetics of the Reserve, impacts on views from private homes, increased exposure to light and glare, impacts to biological resources, impairment of soils stability, reduced sequestration of greenhouse gas emissions, increased fire hazards, hazards from herbicide usage, impacts to water runoff patterns and water quality, increased noise exposure, and changes in wind patterns. Other members of the public expressed the opinion that the project would have beneficial effects. Comments received from the public are summarized under each environmental section in this EIR.

**Table 2.0-1**
**Summary of Impacts and Mitigation Measures**

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **4.1 Aesthetics** | | | |
| **Impact AES-1** | | | |
| The proposed project could have a substantial adverse effect on a scenic vista. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact AES-2** | | | |
| The proposed project could substantially degrade the existing visual character or quality of the site and its surroundings. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact AES-3** | | | |
| Proposed project activities could have a substantial cumulative adverse effect on a scenic vista, or substantially degrade the existing visual character or quality of the site and its surroundings. | Less than significant | No mitigation measure required. | Less than significant |
| **4.2 Air Quality** | | | |
| **Impact AIR-1** | | | |
| The proposed project could conflict with or obstruct implementation of the applicable air quality plan. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact AIR-2** | | | |
| The proposed project could violate an air quality standard or contribute substantially to an existing or projected air quality violation (e.g., induce mobile source carbon monoxide (CO) emissions that would cause a violation of the CO ambient air quality standard. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact AIR-3** | | | |
| The proposed project could result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors. | Less than significant | No mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **Impact AIR-4** | | | |
| The proposed project could expose sensitive receptors to substantial pollutant concentrations. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact AIR-5** | | | |
| Exceed the applicable LRDP EIR standard of significance by exposing receptors to toxic air contaminant emissions that (1) result in a cancer risk greater than 10 cancer cases per 1 million people exposed in a lifetime; or (2) for acute or chronic effects, result in concentrations of toxic air contaminant emissions with a Hazard Index of 1.0 or greater. | Less than significant | No mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **4.3 Biological Resources** | | | |
| **Impact BIO-1** | | | |
| The project could have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or U.S. Fish and Wildlife Service. | | | |
| **Impact BIO-1a: Monarch Butterflies.** The proposed project could remove trees that support overwintering aggregation of monarch butterflies. The dense eucalyptus grove provides suitable roosting conditions for wintering monarch butterflies. Removal of any trees supporting such roosts during the wintering season (October-February) would be considered a significant impact. | Significant | **Mitigation Measure BIO-1a**: Prior to any tree removal, if that was to occur in the winter season (October-February), a qualified biologist familiar with monarch butterfly aggregating behavior and habitat shall conduct a survey of all tree removal area for the presence of overwintering monarch butterfly aggregations. The survey shall be conducted in December or January since aggregation is well-established by then. If any trees are identified as supporting monarch butterfly aggregations, such trees shall be clearly marked in the field and on project plans so that a 200-foot buffer could be established around the tree(s) during tree removal operations until the aggregation has dispersed. | Less than significant |
| **Impact BIO-1b: Coastal Triquetrella.** Coastal triquetrella is a moss with a California Rare Plant Rank of 1B and is known from fewer than 10 small coastal occurrences, including one within .01 mile from the project area. It would be considered a significant impact if access or staging areas substantially disturb suitable habitat on open gravel sites. | Significant | **Mitigation Measure BIO-1b:** Prior to project implementation, a qualified biologist familiar with identification of coastal triquetrella shall conduct a survey of all the access and staging areas located in suitable open gravel habitat for the presence of coastal triquetrella. The survey could be conducted at any time of the year because coastal triquetrella is identifiable from vegetative characteristics, year round. If coastal triquetrella is identified as occurring in areas that would be subject to ground disturbance, the occurrence(s) shall be clearly marked in the field and on the project plans so that the areas could be avoided during access and staging operations. | Less than significant |
| **Impact BIO-2** | | | |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| The project could have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or US Fish and Wildlife Service. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact BIO-3** | | | |
| The project could have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact BIO-4** | | | |
| The project could interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.<br>**Impacts BIO-4a Active Bird Nests and BIO-4b Raptor Nesting**: The proposed tree thinning and vegetation removal is proposed to be conducted outside the nesting season for most bird species (February 15-August 15). However, early nesting species such as great horned owl and Anna's hummingbird could potentially be impacted by such activities. Should the proposed tree thinning and other vegetation removal occur during the primary nesting season, these activities could directly impact nesting birds by removing trees or shrubs that support active nests. Construction-related disturbance (e.g., noise, vehicle traffic, personnel working adjacent to suitable nesting habitat) could also indirectly impact nesting birds by causing adults to abandon nests in nearby trees or other vegetation, resulting in nest failure and reduced reproductive potential. As discuss above, in Section 4.1.3, Regulatory Considerations, nests of native birds are protected under the Federal Migratory Bird Treaty Act and California Fish and Game Code. | Significant | **Mitigation Measure BIO-4a:** While it is anticipated that the proposed tree thinning and vegetation removal activities would be scheduled outside of the nesting season, this may not always be feasible. Prior to any tree thinning and vegetation removal activities that would occur between December 15 (for early-nesting species) and August 15, a qualified biologist shall conduct a preconstruction nest survey of all suitable nesting habitat on and within 50 feet of the limits of work. The contractor shall clearly delineate the trees and other vegetation proposed for removal to ensure that the biologist surveys the work area as thoroughly as possible. If the survey indicates the presence of nesting birds, the biologist shall determine the appropriate sized buffer around the nest in which no work would be allowed until the young have successfully fledged or the nest has failed. The size of the buffer shall be determined by the biologist and shall be based on the nesting species and its sensitivity to disturbance. In general, the buffer for raptors is up to 250 feet and the buffers for other bird species are 50 feet. Depending on the bird species, site conditions and the level of disturbance anticipated near the nest, the buffers | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| | | may be increased or decreased. Implementation of Mitigation Measures 4a and 4b would reduce impacts to potential nesting birds and raptors to a less-than-significant level.<br>**Mitigation Measure BIO-4b Raptor Nesting:** In addition, prior to any tree thinning and removal activities, a qualified biologist familiar with raptor nesting habitat shall examine the treatment area for mature trees that should be retained to provide raptor nesting habitat. Dead snags that provide habitat for woodpeckers and other cavity-nesting species should also be retained to the degree possible. Trees and/or snags recommended for retention should be clearly marked both in the field and on the project plans so they are not removed during tree thinning and understory removal activities. Implementation of Mitigation Measures 4a and 4b would reduce impacts to potential nesting birds and raptors to a less-than-significant level. | Less than significant |
| **Impact BIO-5** | | | |
| The project could conflict with any applicable policies protecting biological resources, including any tree preservation policy or ordinance. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact BIO-6** | | | |
| The project could conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact BIO-7** | | | |
| The project could exceed the applicable LRDP EIR standard of significance by damaging or removing heritage or landmark trees or native oak trees of a diameter specified in a local ordinance. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact BIO-8** | | | |
| The proposed project, in combination with other planned and foreseeable future projects, would result in a cumulatively considerable significant impact related to biological resources. | Less than significant | No mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **4.4 Cultural Resources** | | | |
| **Impact CULT-1** | | | |
| The project could cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact CULT-2** | | | |
| The proposed project, in combination with other planned and foreseeable future projects, could result in a cumulatively considerable significant impact related to cultural resources. | Less than significant | No mitigation measure required. | Less than significant |
| **4.5 Geology and Soils** | | | |
| **Impact GEO-1** | | | |
| Proposed forest thinning and root loss could impact erosion and soil stability, resulting in potential landslides. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact GEO-2** | | | |
| Proposed construction of trails could impact erosion and soil stability, resulting in potential landslides. | Significant | **Mitigation Measure GEO-1:** To minimize the potential for soil erosion and landslides, the following measures should be included in trail construction planning:<br>• Prior to the start of construction of new trails, the trail design should be reviewed by an engineer in the context of its potential impact on slope stability and erosion hazards.<br>• Cut slopes associated with the trails will be located in such a way as to avoid undermining the stability of the toe of existing slopes.<br>• Surface runoff will be directed towards swales on the upslope side of the trail.<br>• The trails be reviewed periodically by UCSF staff during the first year following construction and remedial action will be taken to address any evidence of erosion | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **4.6 Greenhouse Gas Emissions** | | | |
| **Impact GHG-1** | | | |
| Proposed vegetation management activities would affect the ability of the Reserve to sequester GHGs, but not at levels that would result in a significant impact on the environment. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact GHG-2** | | | |
| Proposed vegetation management activities would not conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing GHG emissions. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact GHG-3** | | | |
| Equipment operations associated with project implementation would generate GHG emissions, but not at levels that would result in a significant impact on the environment. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact GHG-4** | | | |
| Project implementation would not conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing GHG emissions. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact GHG-5** | | | |
| The proposed vegetation management activities would contribute to cumulative impacts, but not at levels that would result in a significant impact on the environment. | Less than significant | No mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **4.7 Hazards – Fire Hazards** | | | |
| **Impact FIRE-1** | | | |
| The project could expose people or structures to a significant risk of loss, injury or death involving wildland fires. | Significant | Mitigation Measure FIRE-1: To reduce the risk of fire ignition and the spread of fire while implementing management activities, the following measures shall be taken:<br>• Earthmoving and portable equipment with internal combustion engines shall be equipped with a spark arrestor to reduce the potential for igniting a wildland fire (Public Resources Code Section 4442)<br>• Appropriate fire suppression equipment shall be maintained in the vicinity of management activities during the highest fire danger period – from April 1 to December 1 (Public Resources Code Section 4428)<br>• Workers shall carry fire extinguishers in their trucks and use appropriate fire prevention and suppression measures while undertaking management activities<br>• No treatment actions involving motorized equipment shall take place during Red Flag warnings in San Francisco, unless the San Francisco Fire Department specifies precautions to allow their use | Less than significant |
| **Impact FIRE-2** | | | |
| Effects of cumulative management activities could increase the risk of exposure to wildland fire. | Less than significant | No mitigation measure required. | Less than significant |
| **4.8 Hazards – Herbicide Use** | | | |
| **Impact HAZ-1** | | | |
| Human Health Hazard. Use of proposed herbicides on the Reserve could pose a significant risk to human beings. | Less than significant | No project-level mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **Impact HAZ-2** | | | |
| Hazards to Applicators. Use of proposed herbicides on the Reserve could adversely affect herbicide applicators. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HAZ-3** | | | |
| Terrestrial Wildlife Species. Use of proposed herbicides on the Reserve could adversely affect terrestrial wildlife. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HAZ-4** | | | |
| Water Quality and Aquatic Wildlife. Use of proposed herbicides on the Reserve could adversely affect water quality and aquatic wildlife. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HAZ-5** | | | |
| Regional Water Quality and Aquatic Wildlife and Fish. Use of proposed herbicides on the Reserve could adversely affect water quality and aquatic wildlife in San Francisco Bay and the Pacific Ocean. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HAZ-6** | | | |
| Impacts to Vegetation. Use of proposed herbicides on the Reserve could adversely affect native vegetation, including special status species of plants | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HAZ-7** | | | |
| Impacts from Surfactant and Dye. Use of the proposed surfactant and dye would not substantially increase the risk identified in the previous six impacts. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HAZ-8** | | | |
| Cumulative Impacts. Use of the proposed herbicides on the project site could combine with herbicide applications on the adjacent Interior Greenbelt to adversely affect water quality and aquatic wildlife. | Less than significant | No mitigation measure required. | Less than significant |
| **4.9 Hydrology** | | | |
| **Impact HYDRO-1** | | | |
| The project could violate water quality standards or waste discharge requirements. | Less than significant | No project-level mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **Impact HYDRO-2** | | | |
| The project could substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion on- or off-site. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HYDRO-3** | | | |
| The project could substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HYDRO-4** | | | |
| The project could substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HYDRO-5** | | | |
| The project could create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HYDRO-6** | | | |
| The project could require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HYDRO-7** | | | |
| The project could place housing within a 100-year flood hazard area as mapped on a Federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map; or place within a 100-year flood hazard area structures that would impede or redirect flood flows. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HYDRO-8** | | | |
| The project could expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam. | Less than significant | No project-level mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **Impact HYDRO-9** | | | |
| The project could result in inundation by seiche, tsunami, or mudflow. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact HYDRO-10** | | | |
| The project could substantially degrade water quality. | Significant | **Mitigation Measure HYDRO-10:** To further assure project impacts are less than significant, UCSF shall comply with the following measures:<br>• Minimize the use of triclopyr-based herbicides whenever possible and utilize only glyphosate-based herbicides within site Subwatersheds 2 and 3 (Figure 2). Subwatershed 2 surface runoff directly enters adjoining residential properties to the east of the site. Subwatershed 3 drains to Woodland Creek where the Central HQs for accidental spills and overland runoff have the highest potential for exceeding doses of concern for humans and aquatic wildlife. The herbicide risk assessment cites evidence in the research literature that glyphosate-based herbicides appear to be equally effective in cut-stump treatments if stumps are treated immediately after cutting.<br>• Use the lowest concentrations of herbicide possible for cut-stump treatments. The risk assessment noted that efficacy studies indicate that concentrations of glyphosate and triclopyr products as low as five percent can be as effective as 50–100 percent solutions if stumps are treated immediately after cutting. Use of a more dilute herbicide solution will also allow for treatment of more trees per acre, thereby avoiding limitations in the number of trees that can be treated.<br>• Cut vegetation prior to treatment to minimize the potential for direct sprays to wildlife and contact with treated vegetation for workers, the general public, and terrestrial wildlife.<br>• Apply herbicides as early as possible in the summer to allow time for degradation to occur prior to the rainy season when possible. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| | | • Change spill-handling procedures to require thorough cleanup of all spills to puddles and to the land.<br>• To the extent feasible, fill topographic depressions with soil where puddles might form near heavily treated areas in order to reduce the probability that overland flow from treated sites would contaminate areas that could be used as amphibian breeding habitat.<br>• Create a 25-ft. herbicide- application setback zone along Woodland Creek to provide a water quality buffer zone and to minimize opportunities for direct entry of accidentally spilled herbicides to the Creek.<br>• Maintain an on-site environmental monitor with knowledge of and experience in safety and cleanup procedures with respect to herbicide application to monitor the contractor retained to implement this portion of the management plan. Ensure that the on-site monitor is fully conversant with the project guidelines for herbicide handling, storage and cleanup, including those cited as additional mitigation measures herein. | |
| **Impact HYDRO-11** | | | |
| The project could result in a substantial adverse cumulative effect with regard to hydrology and water quality. | Less than significant | No mitigation measure required. | Less than significant |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| **4.10 Noise** | | | |
| **Impact NOISE-1** | | | |
| Proposed forest thinning and understory removal activities in the Edgewood area could expose nearby residents to a substantial increase in noise levels. | Significant | **Mitigation Measure NOISE-1**: To reduce the degree of increased noise levels to which residents may be exposed, the following measures shall be taken:<br>• The University shall limit to the extent feasible trees and/or vegetation to be removed within the eastern stretch of forested land between the northern end of Medical Center Way and the Surge building, adjacent to the rear yards of Edgewood Avenue residences, while achieving its goals of improving forest health and reducing the risk of wildfire.<br>• The University shall consider any requests by residents adjacent to these areas to plant trees and/or vegetation that may be less flammable than eucalyptus, to provide some degree of noise buffering.<br>• The University shall continue efforts to upgrade and replace rooftop mechanical equipment to reduce over time ambient noise levels to achieve the 50/55 dBA goal. | Significant and Unavoidable |
| **Impact NOISE-2** | | | |
| Proposed forest thinning and understory removal activities could have a substantial adverse cumulative effect with regard to exposing nearby residents to increased noise levels. | Less than significant | No mitigation measure required. | Less than significant |
| **4.11 Wind** | | | |
| **Impact WIND-1** | | | |

| Environmental Topic and Impact | Level of Significance before Mitigation | Mitigation Measures | Level of Significance after Mitigation |
|---|---|---|---|
| The proposed project could have a substantial adverse short-term windthrow-related effect on the safety of people or structures. | Significant | **Mitigation Measure WIND-1:** After thinning, the project area would be regularly monitored by an urban forester or arborist to access tree health and condition. Trees prone to windthrow, e.g. dead or diseased trees or those occurring on steep slopes with limited soil for rooting, and considered a hazard to people or structures would be removed. The implementation of this measure would reduce the short-term impact of windthrow to a less than significant level. | Less than significant |
| **Impact WIND-2** | | | |
| The proposed project could have a substantial adverse long-term windthrow-related effect on the safety of people or structures. | Less than significant | No project-level mitigation measure required. | Less than significant |
| **Impact WIND-3** | | | |
| The project could have a substantial adverse effect on wind environments in local neighborhoods. | Less than significant | No project-level mitigation measure required. | Less than significant |

**Table 2.0-2**
**Summary Comparison of Project Alternatives**

| Mount Sutro Management Project Impact | | Proposed Project (Before Mitigation) | No Project Alternative | Reduced Project Alternative |
|---|---|---|---|---|
| NOISE-1 | Proposed forest thinning and understory removal activities in the Edgewood area could expose nearby residents to a substantial increase in noise levels. | **Significant** | No impact | No impact |
| New Impact (related to No Project Alternative) | Decline in forest health could have a substantial negative affect on the aesthetics of the Reserve. | Less than Significant | Significant | Less than significant |
| New Impact (related to No Project Alternative) | Decline in forest health could have a substantial negative affect on the biological resources in the Reserve. | Less than Significant | Significant | Less than significant |

# CHAPTER 3

# PROJECT DESCRIPTION

The University of California, San Francisco (UCSF) proposes to implement a number of management activities in the UCSF Mount Sutro Open Space Reserve ("Reserve") at its flagship campus site at Parnassus Heights. Proposed management activities include forest-thinning and removal of understory vegetation to reduce the risk of a wildfire and to improve forest health; removal of dead, dying, unhealthy and hazardous trees; native plant restoration and enhancement; conversion planting (removal of non-native trees and plants and conversion to native species); and the creation of new trails.

## 3.1 PROJECT LOCATION AND SURROUNDING USES

The University-owned Reserve is a largely undeveloped 61-acre forest located within UCSF's Parnassus Heights campus site near the geographical center of San Francisco (see Figures 3-1 and 3-2). The Reserve is surrounded by the UCSF campus -- UCSF's hospital, research, educational and support structures to the north/northwest -- and by urban residential neighborhoods to the south, east and west (see Figure 3-3). In addition, the Interior Greenbelt natural area, owned by the City and County of San Francisco, is adjacent to the east side of Reserve.

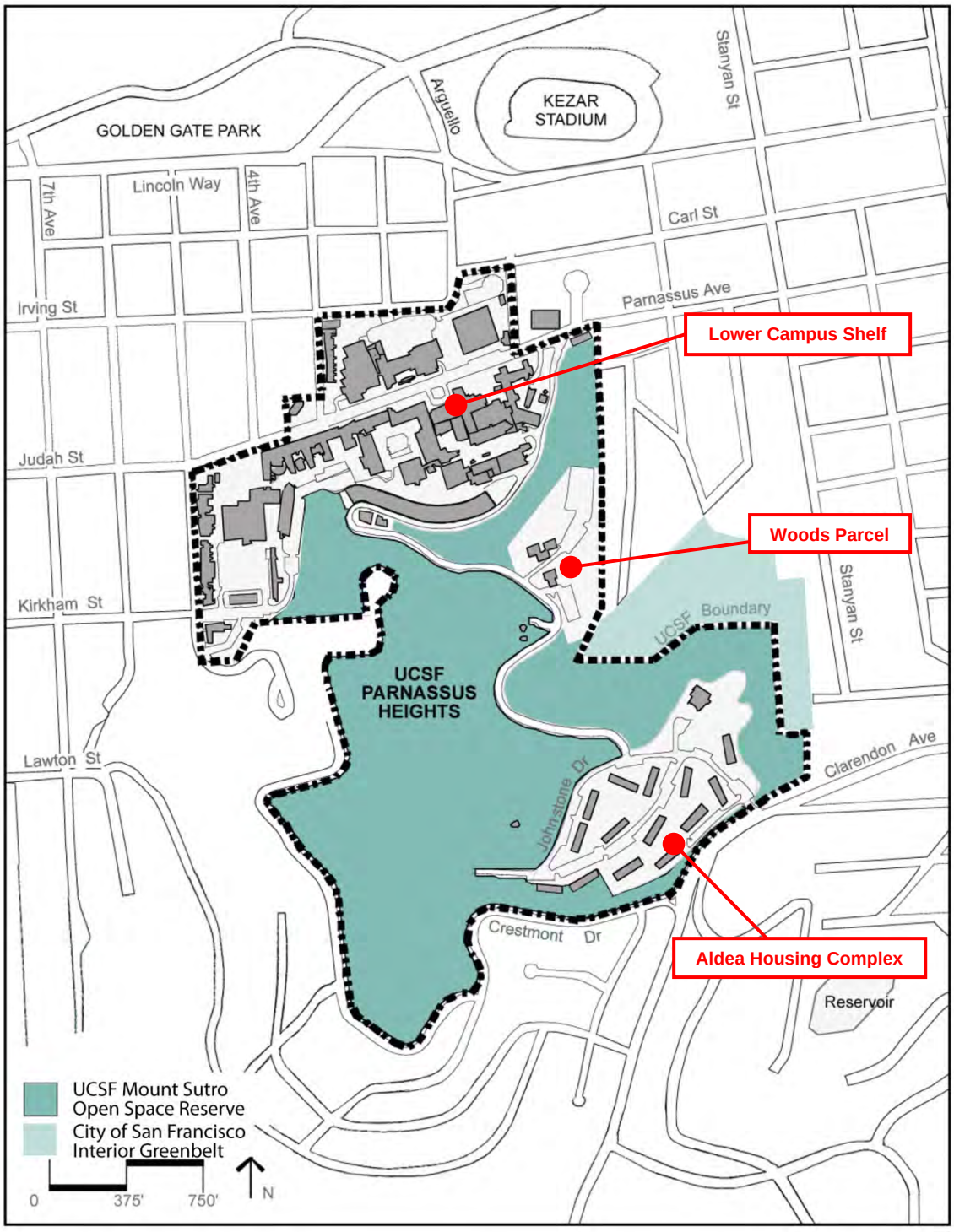
The UCSF Parnassus Heights campus site is the oldest and largest of the UCSF campus sites, occupying about 107 acres of land at the base of Mount Sutro, in the Inner Sunset neighborhood of San Francisco. The Parnassus Heights campus site is generally bounded by Carl and Irving Streets to the north, 5th Avenue to the west, and Clarendon Avenue, Christopher Drive and Crestmont Drive to the south. To the east, the campus extends east of Medical Center Way, but west of Edgewood Avenue and west of the Interior Greenbelt. The UCSF Mount Sutro Open Space Reserve occupies the southern portion of the campus site.

The slopes of Mount Sutro have limited development of the Parnassus Heights campus site to three main areas: (1) the Aldea student housing complex near the summit of Mount Sutro, which provides housing for about 175 students and their families, for a total of about 300 people, and a community center; (2) the Lower Campus shelf at the northern end of the site, which contains UCSF's main academic, clinical and research facilities at Parnassus Heights totaling approximately 3.8 million gross square feet (gsf) of development plus parking, and housing along Third and Fifth Avenues; and (3) the Woods parcel on the hillside in the center of the site, which contains support functions, offices, and surface parking. The Reserve occupies the remaining 61 acres of the campus site. The Reserve, designated as permanent open space by The Regents of the University of California, is open to the public and serves as a point of respite and recreation not only for UCSF, but for the greater community.

| | | | | | |
|---|---|---|---|---|---|
| 1 | Parnassus Heights | 8 | Hunters Point | 14 | 220 Montgomery Street |
| 2 | Mission Bay | 9 | Oyster Point | 15 | 1930 Market Street |
| 3 | Mount Zion | 10 | San Francisco General Hospital (Affiliation) | 16 | 982 Mission Street |
| 4 | Laurel Heights | 11 | Veterans Affairs Medical Center (Affiliation) | 17 | 2300 Harrison Street |
| 5 | Buchanan Dental Clinic | 12 | 185 Berry Street | 18 | 2727 Mariposa Street |
| 6 | Mission Center Building | 13 | 50 Beale Street | 19 | 3360 Geary Boulevard |
| 7 | 654 Minnesota Street | | | 20 | 250 Executive Park Boulevard |

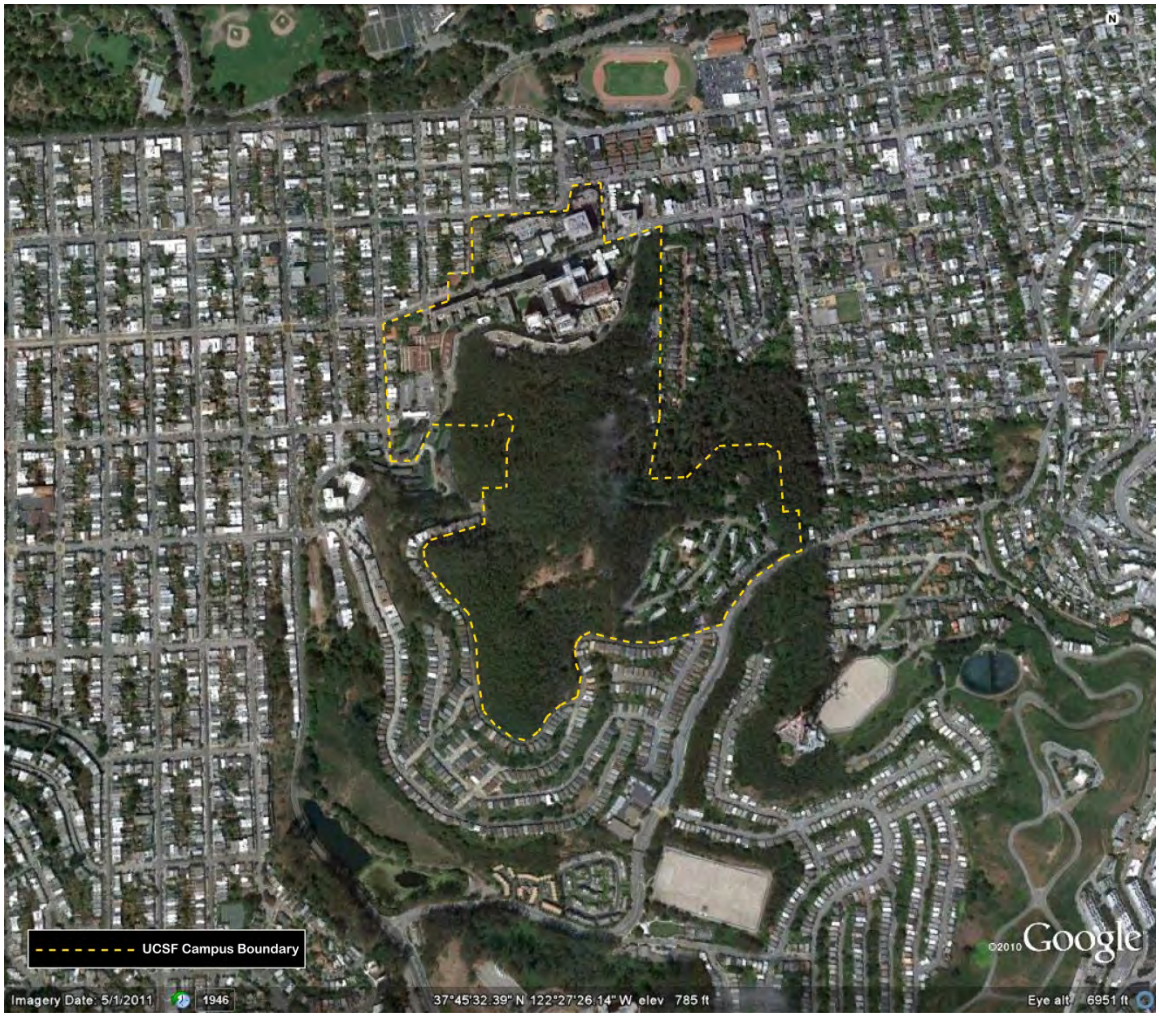
Source: UCSF

**Figure 3-1**
UCSF Campus Sites
Project Site at Parnassus Heights




Source: UCSF

**Figure 3-2**
UCSF Mount Sutro Open Space Reserve




Source: Google Earth and UCSF

**Figure 3-3**
UCSF Mount Sutro and Environs

The neighborhoods surrounding the Parnassus Heights campus site and the Reserve include the Inner Sunset to the west and north, a primarily residential neighborhood with a neighborhood-serving commercial district along Irving Street; Cole Valley to the east, also primarily residential with a neighborhood commercial district along Cole Street; the Haight/Ashbury (bordering Cole Valley), also primarily residential with a neighborhood commercial district along Haight Street that is also a destination for tourists; and Forest Knolls and Midtown Terrace to the south, both low-density residential neighborhoods. The US Census for 2010 shows that approximately 44,700 persons reside in these neighborhoods.[1]

The City and County of San Francisco's Interior Greenbelt is adjacent to the east side of the Reserve. The Interior Greenbelt is a public open space identified as one of the City's "natural areas," and management of the City's natural areas, including the Interior Greenbelt, is discussed

[1] 2010 Census Data for tracts 171.01, 171.02, 204.01, 204.02, 301.01, 301.02, 302.02, 303.01, 303.02, 304, and 305.

in the *Significant Natural Resource Areas Management Plan* (SNRAMP), February 2006, prepared by the San Francisco Recreation and Park Department. A Draft Environmental Impact Report prepared for the plan was published on August 31, 2011. As of the publication date of this Draft EIR for the UCSF Mount Sutro Management project, the SNRAMP EIR has not been finalized.

## 3.2 CONDITION OF THE RESERVE

The Reserve is dominated (82%) by blue gum eucalyptus, planted in the late 1800s. Other tree species include Monterey pine, Monterey cypress, blackwood acacia, and coast redwood. The understory is thick with Himalayan blackberry, and other non-native and native shrubs and vines. According to the UCSF Mount Sutro Open Space Reserve Management Plan, the regeneration and spread of blue gum eucalyptus has been prolific because the trees are very adaptable to the conditions of the site, they re-sprout vigorously, and they suppress the growth of other plant species. The oils in the foliage and bark inhibit the seed germination and early plant growth of many other plants. It is estimated that there are approximately 45,000 or more trees in the Reserve, but most are very young, small trees. Most trees are less than 12 inches in diameter.

The Mount Sutro Open Space Reserve Management Plan indicates that, as with any monocultural (i.e. single species) forest, the trees of the Reserve are particularly prone to widespread disease and wildfire.[2] Their vulnerability will increase as more trees become stressed from greater competition with one another and as more die. The denser and more stressed the trees become, the more they are susceptible to infestation by pests.

A report on the condition of the Reserve was prepared in 1999 by HortScience.[3] At that time, HortScience determined that the general condition of the Reserve's trees is only fair to good, but the prevalent small trees throughout the forest are generally in worse condition than the large trees that dominate the forest canopy. The overall condition of eucalyptus saplings was assessed as poor, and most of the standing dead trees observed by HortScience were less than six inches in diameter. The regeneration and recruitment of eucalyptus into the forest canopy is limited, and little regeneration is occurring even when trees fall and create gaps in the canopy. The rampant growth of English ivy, Himalayan blackberry and other invasive exotic species further impedes regeneration. According to HortScience, without healthy regeneration through proactive management, the forest will continue to decline, and may eventually be overtaken by the invasive understory of shrubs and ivies.[4] Since preparation of the HortScience report, arborists retained by UCSF have observed that conditions in the Reserve have deteriorated. Dense spacing and predominance of small trees continues today. More trees are in decline, sapling health remains poor, and fuel loads have increased.

[2] UCSF Mount Sutro Open Space Reserve Management Plan, September 2001, p. 21.

[3] UCSF Mount Sutro Open Space Reserve Maintenance and Restoration Plan, July 1999, prepared by HortScience

[4] UCSF Mount Sutro Open Space Reserve Management Plan, September 2001, p. 21.

## 3.3 PROJECT OBJECTIVES

Section 15124(b) of the *State CEQA Guidelines* requires that the project description in an EIR include "a statement of the objectives sought by the applicant," which should include "the underlying purpose of the project." The primary objectives of the proposed management actions fall into four broad categories:

- to improve safety for the people and property in the environs of the Reserve
- to enhance the overall health of the Reserve
- to improve the aesthetics of the Reserve
- to increase the usability of the Reserve

The specific objectives of the proposed project, as described in the *UCSF Mount Sutro Open Space Reserve Community Planning Process Summary Report*, November 2010, are:

Safety

- To reduce fuel load and potential for wildfires
- To provide emergency response access
- To remove hazardous trees near trails, roads and structures
- To improve trailside visibility
- To facilitate long-term maintenance

Health

- To reduce competition among trees (increase growing space, soil/plant moisture and fertility)
- To remove diseased and unhealthy trees
- To create a variety of tree ages
- To increase tree species diversity
- To remove vines from tree trunks
- To monitor and sustain the health of the forest

Aesthetics

- To maintain a forested setting
- To maintain attractive healthy trees
- To improve visibility within the forest
- To enhance view corridors from the Reserve

Usability

- To maintain adequate path and trailside clearance
- To place logs for seating along trails and to close unauthorized trails
- To modify steep trail segments with switchbacks
- To enrich habitat and enhance the outdoor experience of the Reserve's users

# 3.4 BACKGROUND

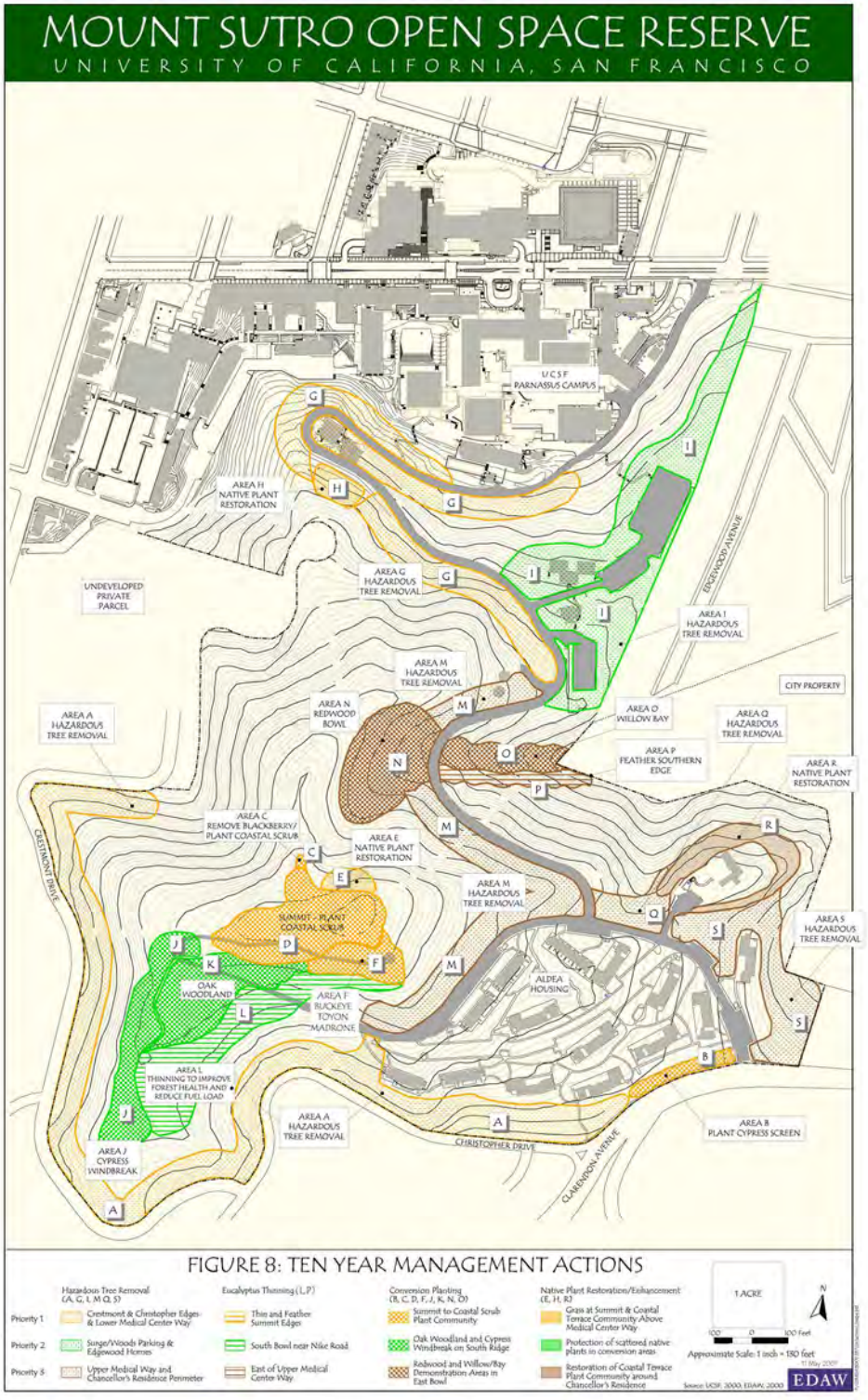
## 3.4.1 MOUNT SUTRO OPEN SPACE RESERVE MANAGEMENT PLAN

In 1996, UCSF prepared a Long Range Development Plan (LRDP) to guide the physical development of the campus. The LRDP reaffirmed UCSF's commitment to maintain the Reserve as permanent open space and included a proposal to investigate an appropriate maintenance and restoration program for trees and vegetation in the Reserve, which was showing signs of distress and degradation. To fulfill this proposal, the Mount Sutro Open Space Reserve Management Plan, prepared with extensive community involvement, was completed in 2001 and serves as a framework for future management activities. The principal purpose of the Management Plan was to outline measures to restore and maintain the health of the Reserve and to minimize safety risks. The Management Plan identified five near-term management actions for the Reserve that could be implemented within approximately ten years (see Figure 3-4). These near-term activities included:

- hazardous tree removal near buildings and pavement (approximately 18 acres averaging about 15 trees per acre)
- eucalyptus thinning in two demonstration areas (total 2.5 acres)
- conversion planting to native and other appropriate species of trees, shrubs and other plants in eight demonstration areas (total 7.6 acres)
- native plant enhancement around three existing known native plant communities
- trail system improvements, including new trails and switchbacks

Under the adaptive management approach discussed in the Management Plan, specific longer-term management actions were to be informed by the evaluation of the near-term management activities and the Reserve's future needs for an additional twenty years. The Management Plan foresaw that the longer-term management activities would include continued expansion of the near-term management actions, specifically:

- incremental eucalyptus thinning elsewhere in the Reserve where trees are particularly dense, except on the western slopes where the terrain is too steep or otherwise inaccessible
- expansion of buckeye, toyon and madrone south of the summit
- expansion of oak woodland mix in the south bowl and planting on the eastern boundary near Edgewood Avenue
- redwood planting on the north-facing slope above the main developed area of the campus
- willow/bay planting in the area along the intermittent creek along the east side of the Reserve
- removal of additional potentially hazardous trees along Medical Center Way to help serve as a fire break.




Source: UCSF

**Figure 3-4**
2001 Management Plan
10-year Management Actions

Since 2001, various activities described in the Management Plan have been implemented, including:

- hazardous tree removal near the Crestmont Avenue and Christopher Drive; along Medical Center Way; near the Surge Building; near Aldea housing and the Chancellor's residence; and along Nike Road
- native plant restoration and enhancement at the summit of Mount Sutro (i.e. the Rotary Meadow)
- screen planting at the Aldea housing complex
- cleared and improved trails, including trail markers
- regular maintenance of the Reserve including pruning and removal of invasive vegetation

Many of these activities were accomplished in large part by the Mount Sutro Stewards, a community-based volunteer organization, in coordination with the UCSF Facilities Management department. These activities were considered maintenance or minor in scope under the California Environmental Quality Act (CEQA) and were exempt from CEQA review.

The 2001 Management Plan is a framework for management of the forest and continues to serve as a guide. However, specific plans for management continue to evolve as priorities change, remnant native plant communities are discovered, and new community members become involved and provide feedback to UCSF. In addition, the health of the forest has declined since the Plan was prepared. To address these changes, the proposed management activities may differ somewhat from those discussed in the 2001 Management Plan. These differences may include the number and sizes of demonstration areas, and in some cases some variation in the types of management actions proposed to occur within specific geographic areas. The overall intent of proposed management activities, however, remains the same: to improve safety, to enhance the overall health of the Reserve, to improve its aesthetics, and to increase its usability.

## 3.4.2 COMMUNITY PLANNING PROCESS

In recognition of the need to maintain ongoing dialogue with the community regarding the management of the Reserve, UCSF initiated a new round of community meetings in 2009 that carried into 2010. The process resulted in identifying demonstration project areas and specific management actions for those demonstration areas, which form the basis of the proposed project. More information about the community process can be found in the "Community Planning Process Summary Report," November 2010.[5]

[5] The "Community Planning Process Summary Report" is available online at http://www.ucsf.edu/sites/default/files/documents/ucsf_sutroreport_111710.pdf

## 3.5 PROJECT DESCRIPTION

The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and plants and conversion to native species). Vegetation management actions are proposed to occur throughout the Reserve over many years. Under full or worst-case implementation of management activities under the proposed project, approximately 60% of all the existing trees, including large and small trees, could be removed from the Reserve, the majority of which would be small trees less than 12 inches in diameter. Implementation would be phased beginning with four demonstration projects that were crafted with the interested public in the community process described below.

The first three demonstration projects are planned for implementation following the completion of environmental review and project approval. The fourth demonstration project would be implemented approximately one year after the first three demonstration projects to incorporate lessons learned from the first three demonstration projects. Also, the proposed project would include a "Hands-Off" management area at the request of some community members. In the Hands-Off management area, no vegetation management would be undertaken for the one-year duration of the first three demonstration projects.

The demonstration projects would include a range of potential management actions that could be implemented later throughout the entire Reserve. Such actions would be first implemented in these four small areas to "demonstrate" to the public the range of potential results. Public feedback would then inform the University's choices in the management activities to be applied to the remainder of the Reserve over time. The management actions identified for the demonstration areas are proposed to be applied ultimately beyond the demonstration areas to the remainder of the Reserve, as appropriate, subject to further refinement by UCSF in consultation with the interested public (see Figure 3-5). Accordingly, this EIR conservatively analyzes environmental impacts resulting from the full range of management activities proposed for the entire 61-acre Reserve.

Several principles will govern the implementation of management activities, including:

- Adaptive Management: UCSF is committed to the principle of adaptive management as defined in the 2001 Plan, allowing for public input and opinion and adjustment of management activities before application to other areas of the Reserve.[6]
- Limited Use of Herbicides: Where herbicide use is indicated, targeted spot-application methods would be employed on tree stumps, vine, blackberry and broom stems, and on poison oak adjacent to trails.
- Tree Spacing: Where tree removal is indicated, the priority for removal is dead, dying, unhealthy, and hazardous trees. Where trees must be removed to achieve desired

[6] Adaptive management is a flexible, learning-based management approach that allows for changes in response to a problem or issue based on new information. Decision-making incorporates monitoring of a situation, learning, and modifying actions if necessary in order improve long-term management outcomes.

spacing, the next priority would be removal of trees smaller than 12 inches in diameter, followed by removal of trees larger than 12 inches in diameter.

The proposed management activities are described below.

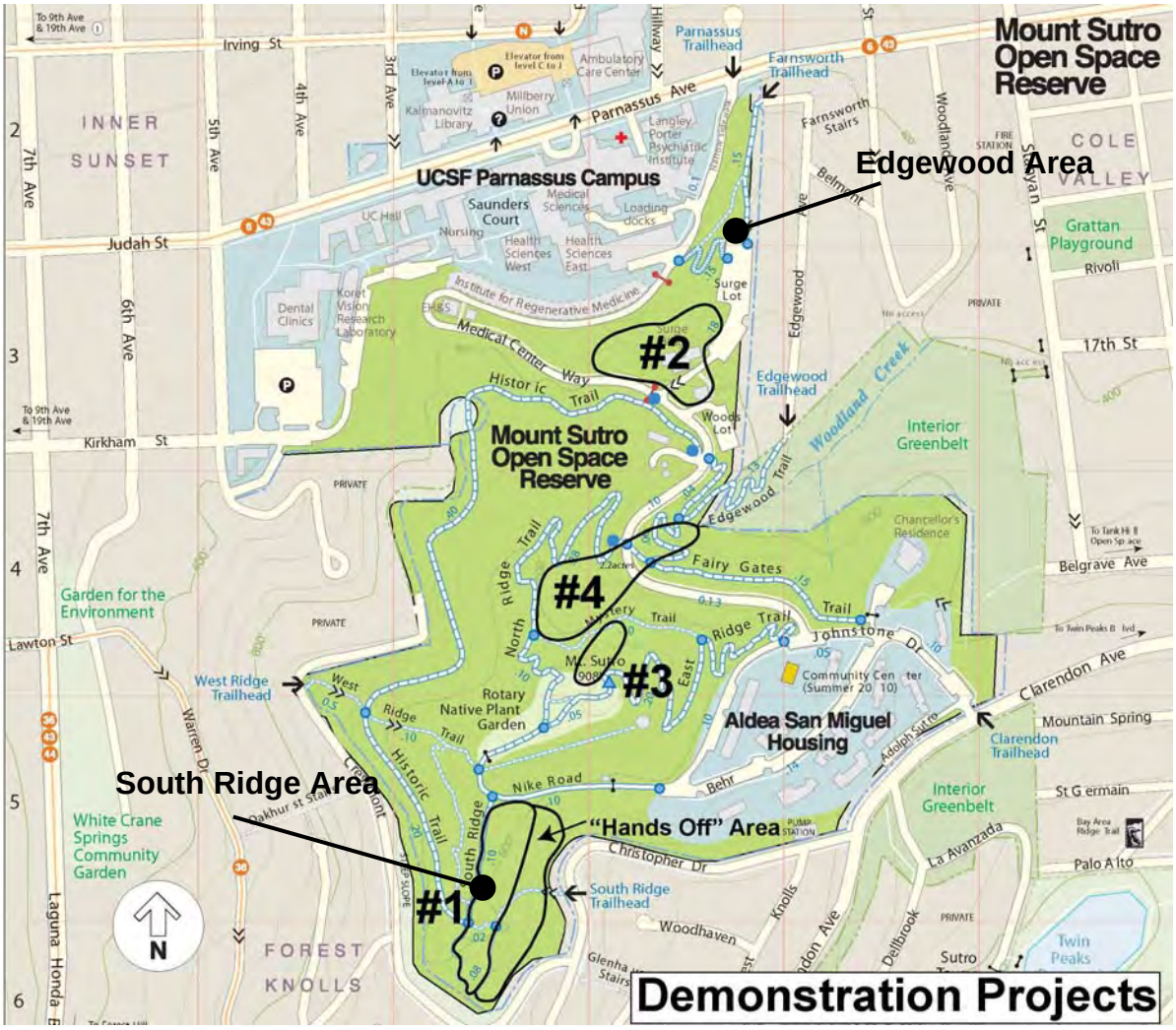



**Figure 3-5**
Proposed Demonstration Project Areas

## 3.5.1 DEMONSTRATION PROJECTS

### 3.5.1.1 #1. SOUTH RIDGE AREA – 3 ACRES

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 30 feet between trunks
- Tree stump treatment: 1 acre – rely on hand maintenance; 1 acre –cover with tarps; 1 acre – apply herbicides
- Sprout control: cut mechanically or use goat grazing 1-2 times per year for 3-5 years in 1 acre where stumps are not tarped or treated with herbicide

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak); islands of brush will be maintained for wildlife
- Spot-treat cut tree vines, blackberry stems and poison oak adjacent to trails with herbicide in 1 acre
- Mow, use goat grazing and/or use herbicides consistent with city standards, annually or every other year for 5 years, depending on rate of re-growth

### 3.5.1.2 #2. EDGEWOOD AVENUE AREA – 2 ACRES

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning minimal, mostly acacias. Of those areas to be thinned, remaining trees to average spacing of about 30 feet between trunks, close to the spacing that currently exists in most of this area
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Initially, mow up to 90-100% (excluding native plants)
- Mow and/or use goat grazing annually or every other year for 5 years, depending on rate of re-growth

### 3.5.1.3 #3: NORTH SIDE OF SUMMIT – <0.5 ACRE

Trees

- Remove trees minimally, only as needed to prevent shading of existing Nootka reed grass area

- Remove trees minimally, only as needed to maintain a clear view corridor to the northeast
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Hand-remove non-native plants from grass area

### 3.5.1.4 #4. EAST BOWL CORRIDOR – 2 ACRES

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 60 feet between trunks
- Tree stump treatment and sprout control would depend on outcome of Demonstration Project 1, but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used
- Planting of native shrubs and trees (1 acre irrigated, 1 acre non-irrigated)

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak along trails); large areas of underbrush are expected to be maintained in this demonstration area
- Re-growth control depends on outcome of Demonstration Project 1 but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used (herbicides would not be used if it can be demonstrated in Demonstration Project 1 that undesirable understory plants can be controlled at a reasonable cost without herbicides.)

### 3.5.1.5 "HANDS- OFF" MANAGEMENT AREA: SOUTH RIDGE AREA – 2 ACRES

Trees

- No changes to existing trees, except that maintenance will be performed to remove and prune hazardous trees near homes and trails for the safety of residents and visitors and to keep trails clear (including trash pick-up).

Understory

- Understory would remain as is
- Trails would be kept clear, including trash removal

## 3.5.2 CONTINUED IMPLEMENTATION

Following the completion and assessment of the Demonstration projects, targeted management actions would potentially be applied to the remainder of the Reserve. For purposes of this EIR, it is assumed that all lands would be subject to the proposed vegetation management actions noted in this Project Description, which include the following:

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 30 feet between trunks, except in Demonstration Area #4, East Bowl Corridor, where average trunk spacing would be roughly 60 feet to accommodate plantings of redwood, willow, and bay trees and native forbs and shrubs.
- In some select areas along trails and at the summit, trees would be removed to create views.
- Steep slopes that are inaccessible by heavy equipment (about 15 acres) would not be thinned.
- The large scale thinning work would be phased – no more than a quarter of the Reserve would be thinned at any given time.
- Tree stump treatment and sprout control would depend on the outcome of the Demonstration Projects, and could include techniques such as covering with tarps, sprout cutting, or goat grazing. For purposes of a conservative EIR analysis, it is assumed, as a worst-case scenario, that herbicides will be used.
- Selective planting of native shrubs and trees.

Regarding the select planting of native shrubs and trees, the 2001 Management Plan discussed conversion planting locations on the summit, in the East Bowl Corridor (Demonstration Area #4), and in the South Ridge Area (including in Demonstration Area #1). As discussed, the summit has been planted with a native plant garden. Conversion planting in the East Bowl Corridor would be completed as part of Demonstration Project #4). The 2001 Management Plan identified for the South Ridge area the planting of Monterey cypress to create a windbreak ("Area J" in the 2001 Management Plan), and the planting of Oak Woodland ("Area K") (see this chapter Figure 3-4). The Monterey cypress windbreak is no longer proposed. In the future, Oak Woodland may be planted in Area K, an area of roughly 1.5 acres, should funding become available.

Of the Reserve's 61 acres, conversion planting would occur in the East Bowl Corridor (about 2 acres) and potentially in Area "K" (about 1.5 acres). Accounting for the summit (about 1.5 acres), about 56 acres of forested area would remain where the predominant species is eucalyptus. Thus, the overwhelming majority of the Reserve would remain a eucalyptus forest, although at a lower density of trees per acre than exists today.

Understory

- Initially, mechanically remove (via mowing, cutting) up to about 90% of the non-native biomass, including poison oak along trails. Large areas of underbrush are expected to be maintained, and steeper slopes (>40 percent) may not be cut at all.
- Re-growth control may be conducted using various techniques including mowing, goat grazing, and/or herbicides, which would be applied annually or every other year for 5 years, depending on the rate of re-growth.

### 3.5.3 TRAILS

Over the past several years, trails have been restored and enhanced to improve access throughout the Reserve for the enjoyment of visitors. For example, an historic trail that was only recently discovered was restored by the Mount Sutro Stewards. Three new trails are proposed as part of the project: (1) a trail on the north side of the Reserve connecting the Historic Trail to the campus, allowing for ease of access to/from the campus; (2) a trail connecting the South Ridge and Quarry Road Trails to Christopher Drive, allowing for easier public access from the south side of the Reserve; and (3) an extension of this new trail to Clarendon Avenue and to trails to the Interior Greenbelt (on City-owned land) and southeast of the Reserve (see Figure 3-6). Proposed trail alignments as shown are approximate and have not yet been designed. The creation of these new trails will require minimal vegetation removal, minor amounts of grading and new trail markers.

### 3.5.4 ONGOING MAINTENANCE

The University, with the assistance of the UCSF Mount Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees, and restoring trails. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

### 3.5.5 BEST MANAGEMENT PRACTICES

The following best management practices (BMPs) are incorporated into the proposed project:

1. Disturbance to existing grades and vegetation will be limited to the actual treatment or restoration areas and necessary access routes. Placement of all trails, staging areas and other facilities will avoid and limit disturbance to existing native plants to the maximum extent practicable, with the exception of poison oak. Where possible, existing ingress or egress points will be used and contours of the work area will be returned to pre-construction conditions.
2. Disturbed soils resulting from treatment activities will be stabilized prior to the rainy season by spreading woodchips or shreds or other mulch materials over the bare ground.

3. Straw wattles, silt fencing, straw bales, or similar sediment control measures will be installed on contours along the lower edge of the treatment areas to prevent excess sediment from entering the watershed, if deemed necessary.
4. To avoid attracting predators, food-related trash will be disposed in closed containers and regularly removed from the work areas.
5. All construction material, wastes, debris, sediments, rubbish, vegetation, trash, fencing, etc., will be removed from the site upon completion of treatments and transported to an authorized disposal area, as appropriate, and per all federal, State and local laws and regulation.
6. All construction-related holes will be covered to prevent entrapment of native amphibians, reptiles and small mammals.

**Figure 3-6**
Existing and Proposed Trails
(Proposed trails are indicated in color)

## 3.6 MITIGATION MEASURES INCLUDED IN THE PROJECT

The following LRDP mitigation measures are included in and made part of the proposed project.

*Mitigation Measure #1: Archaeological Resources:* [modified from LRDP Amendment #2 Hospital Replacement EIR Mitigation Measure 4.3-1, and modified (as shown in underline) from the Initial Study for the UCSF Mount Sutro Management project] Grading and soil disturbance associated with the proposed project could cause substantial adverse changes to archaeological resources at the project site. Should an archaeological artifact be discovered at the site during ground disturbance activities, pursuant to CEQA Guidelines 15064.5(f), "provisions for historical or unique archaeological resources accidentally discovered during construction" should be instituted. In the event that any prehistoric or historic subsurface cultural resources are discovered during ground disturbing activities, all work within 100 feet of the resources shall be halted and UCSF shall consult a qualified archaeologist/paleontologist to assess the significance of the find (per Public Resources Code Section 5024.1, Title 14 California Code of Regulations, Section 4852 and/or Public Resources Code 21083.2 in the event of a unique archaeological find). If any find is determined to be significant and will be adversely affected by the project, representatives of UCSF and the qualified archaeologist/paleontologist would meet to determine the appropriate avoidance measures or other appropriate mitigation (per CEQA Guidelines 15064.5(b) and Public Resources Code 21083.2). All significant cultural materials recovered shall be subject to scientific analysis, professional museum curation, and documented by the qualified professional according to current professional standards (per the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44716)). If the discovery includes human remains, CEQA Guidelines 15064.5 (e)(1) shall be followed. In the event of the accidental discovery or recognition of any human remains in any location other than a dedicated cemetery, steps to be taken include:

> (1) There shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until:
>
> (A) The coroner of the county in which the remains are discovered must be contacted to determine that no investigation of the cause of death is required, and
>
> (B) If the coroner determines the remains to be Native American: i) The coroner shall contact the Native American Heritage Commission within 24 hours. ii) The Native American Heritage Commission shall identify the person or persons it believes to be the most likely descended from the deceased Native American. iii) The most likely descendent may make recommendations to the landowner or the person responsible for the excavation work, for means of treating or disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in Public Resources Code Section 5097.98, or
>
> (2) Where the following conditions occur, the landowner or his authorized representative shall rebury the Native American human remains and associated grave goods with

appropriate dignity on the property in a location not subject to further subsurface disturbance.

(A) The Native American Heritage Commission is unable to identify a most likely descendent or the most likely descendent failed to make a recommendation within 24 hours after being notified by the commission.

(B) The descendant identified fails to make a recommendation; or

(C) The landowner or his authorized representative rejects the recommendation of the descendant, and the mediation by the Native American Heritage Commission fails to provide measures acceptable to the landowner.

*Mitigation Measure #2: Construction Noise:* [from the UCSF Medical Center at Mission Bay EIR, Mitigation Measure MCMB.5-1, and modified (as shown in underline from the Initial Study for the UCSF Mount Sutro Management project] Use of heavy equipment for management activities would, on a temporary basis, elevate noise levels in and around the project site, and particularly at nearby sensitive receptors. UCSF shall require contractors to minimize construction noise impacts by use of proper equipment and work scheduling. Construction hours shall be limited to the following schedule:

- Monday through Friday, 7 a.m. to 5 p.m. for not noisy work (80 decibels or less at 100 feet)
- Monday through Friday, 8 a.m. to 5 p.m. for noisy work (more than 80 decibels at 100 feet)
- Extended hours only with advanced notice from the UCSF project manager (Monday through Friday, 5 p.m. to 8 p.m.; Saturday 7 a.m. to 8 p.m.; and Sunday 8 a.m. to 4:30 p.m.)
- No noisy work on Saturdays and Sundays.
- Designate a UCSF community contact person to receive and resolve construction complaints.

## 3.7 MITIGATION MONITORING

CEQA requires that when a public agency makes findings of significance based on an EIR, the public agency must adopt a reporting or monitoring program to ensure that action is completed on those mitigation measures which it has adopted, or made a condition of project approval, in order to mitigate or avoid the project's significant effects on the environment (Public Resources Code Section 21081.6). Upon certification of this EIR and approval of the proposed project, a mitigation monitoring program would be adopted.

## 3.8 REQUIRED APPROVALS

Action by The Regents (including any Regents-delegated committee or official): Upon certification of the EIR, The Regents or its designee will consider whether to approve the proposed management actions.

Action by Other Agencies: There are no responsible agencies that have approval authority over the proposed project. Trustee agencies include the California Department of Fish and Game.

# CHAPTER 4

# ENVIRONMENTAL SETTING, IMPACTS, AND MITIGATION MEASURES

## 4.0 INTRODUCTION

This section of the Environmental Impact Report (EIR) presents potential environmental impacts of the proposed project. The scope of the analysis and key terms are presented below to assist readers in understanding the manner in which the impact analysis has been conducted in this EIR.

### 4.0.1 APPROACH TO IMPACT ANALYSIS

The preparation of this EIR was preceded by an Initial Study (included in Appendix A). The Initial Study evaluated the existing physical conditions on the project site and determined which environmental topics require further analysis in the EIR. The topics that the Initial Study determined would be studied further in the EIR are: Aesthetics, Air Quality (during implementation period of management activities), Biological Resources, Cultural Resources (cultural landscapes), Geology and Soils (landslides), Greenhouse Gas Emissions, Hazards and Hazardous Materials (forest fires, herbicide use), and Noise. Following the publication of the Initial Study, a public scoping meeting was held to receive public comment on the Initial Study and the topics to be analyzed in the EIR. Based on oral comments received at the public scoping meeting and on written comments received during the 30-day public comment period (see Appendix A for written comments received), the following topics were added to the scope of the EIR analyses: Hydrology and Wind.

The following topics were determined in the Initial Study to require no further analysis in the EIR: Agriculture and Forestry Resources, Land Use/Planning, Mineral Resources, Population/Housing, Public Services, Recreation, Transportation/Traffic, and Utilities/Service Systems. Accordingly, these topics are not discussed in this EIR.

For each of the resource areas evaluated in the sections that follow, the EIR describes the existing environmental setting, the potential for the proposed project to significantly affect the existing resources, and recommended mitigation measures that could reduce or avoid potentially significant impacts. Each of the resource sections also clearly identifies those impacts that were determined in the Initial Study to be less than significant, and thus, do not require detailed evaluation in this EIR.

Relevant mitigation measures adopted by The Regents in conjunction with the approval of the 1996 LRDP, LRDP Amendment #2, and the Medical Center at Mission Bay, are included in and

made a part of the proposed project. The analysis presented in the subsequent sections evaluates environmental impacts that would result from project implementation after the application of these mitigation measures.

## 4.0.2 LEVELS OF SIGNIFICANCE

The EIR uses a variety of terms to describe the levels of significance of adverse impacts identified during the course of the environmental analysis. The following are definitions of terms used in this EIR:

- **Significant and Unavoidable Impact.** Impacts that exceed the defined standards of significance and cannot be eliminated or reduced to a less than significant level through the implementation of feasible mitigation measures.

- **Significant Impact.** Impacts that exceed the defined standards of significance and that can be eliminated or reduced to a less than significant level through the implementation of feasible mitigation measures.

- **Potentially Significant Impact.** Significant impacts that may ultimately be determined to be less than significant; the level of significance may be reduced in the future through implementation of policies or guidelines (that are not required by statute or ordinance), or through further definition of the project detail in the future. Potentially Significant Impacts may also be impacts about which there is not enough information to draw a firm conclusion; however, for the purpose of this EIR, they are considered significant. Such impacts are equivalent to Significant Impacts and require the identification of feasible mitigation measures.

- **Less Than Significant Impact.** Impacts that are adverse but that do not exceed the specified standards of significance.

- **No Impact.** The project would not create an impact.

## 4.0.3 ANALYSIS OF CUMULATIVE EFFECTS

The geographic extent of potential project-related cumulative effects differs according to environmental topic. For each environmental topic area, the analysis specifies the geographic scope of the cumulative impact, considers whether implementation of the proposed project in conjunction with past, present and probable future projects would result in adverse cumulative impacts, and finally, determines whether the proposed project's contribution to that effect would be "cumulatively considerable." Cumulative impacts are discussed under each environmental topic.

# 4.1 AESTHETICS

## 4.1.1 INTRODUCTION

This section addresses the existing visual characteristics of the project site and the surrounding area, and evaluates the significance of the change in visual characteristics that would result from the proposed project.

Comments related to aesthetics received during the Initial Study/EIR scoping process included concerns about the following:

- Impacts on views
- Impacts on views from private residences
- Aesthetic qualities of the forest following vegetation management
- Increased light and glare exposure from the Aldea Housing complex due to trail construction and vegetation removal

Other commenters expressed opinions that the aesthetics of the forest would be improved with the proposed project.

## 4.1.2 ENVIRONMENTAL SETTING

The project is located within the City and County of San Francisco, a relatively dense urban environment that is developed in most areas with a diverse mix of land uses. As discussed in Chapter 3, Project Description, the University-owned Reserve is a largely undeveloped 61-acre forest located within UCSF's Parnassus Heights campus site near the geographical center of San Francisco.

Located in a city of many hills and valleys, Mount Sutro is one of San Francisco's 47 hills.[1] It rises approximately 908 feet above sea level and is the northernmost peak of what was once known as the San Miguel Hills, which included nearby Twin Peaks and Mount Davidson. Mount Sutro as it is known today includes the Reserve as well as the Interior Greenbelt area, which is owned and managed by the City and County of San Francisco. Like the Reserve, the Interior Greenbelt is also forested primarily with blue gum eucalyptus trees. The Interior Greenbelt abuts the Reserve on its eastern edge and the two areas are physically and visually contiguous. The Interior Greenbelt property includes a sliver of forested land on the southeast side of Clarendon Avenue. Immediately south of that site is Sutro Tower, a television, radio and wireless communications transmission tower that rises to approximately 1,800 feet above mean sea level. It has become a visual landmark on the San Francisco landscape, visible even from Marin County and the East Bay.

[1] Hansen, Gladys (1995). *The San Francisco Almanac* (Third Ed.), pg. 237.

The Reserve is surrounded by the UCSF campus -- UCSF's hospital, research, educational and support structures to the north/northwest -- and by urban residential neighborhoods to the south, east and west (see Figure 4.1-1). On the north side of the Reserve, the main developed portion of the UCSF campus is distinguished by a cluster of large institutional buildings that front Parnassus Avenue – Moffitt and Long Hospitals, the Medical Sciences Building, the Clinical Sciences Building, UC Hall, and the Ambulatory Care Center. Less visually prominent are the Health Sciences East and West towers, the Regeneration Medicine building, the Dentistry building, and the Vision Research Building. Lower-lying buildings north of Parnassus Avenue include Millberry Union, the Library, and the campus parking structures.

The neighborhoods surrounding the Parnassus Heights campus site and the Reserve include the Inner Sunset to the west and north, the Haight/Ashbury to the east, and Forest Knolls and Midtown Terrace to the south. These are primarily residential neighborhoods with some neighborhood-serving commercial streets, generally developed with two to four-story buildings, with few exceptions.

Source: UCSF

**Figure 4.1-1**
Aerial View Looking South

## Views of the Reserve

From long-range vantage points, the Reserve may be viewed as part of a network of hills and open spaces across the central/western portion of San Francisco, along with nearby Golden Gate Park, Twin Peaks, Mount Davidson, and others. The Reserve stands out in the landscape and is dominant from mid- and short-range vantage points, particularly from the north, east and west. The Reserve provides a dramatic visual contrast from the structures that surround it (see Figures 4.1-2 to 4.1-13).

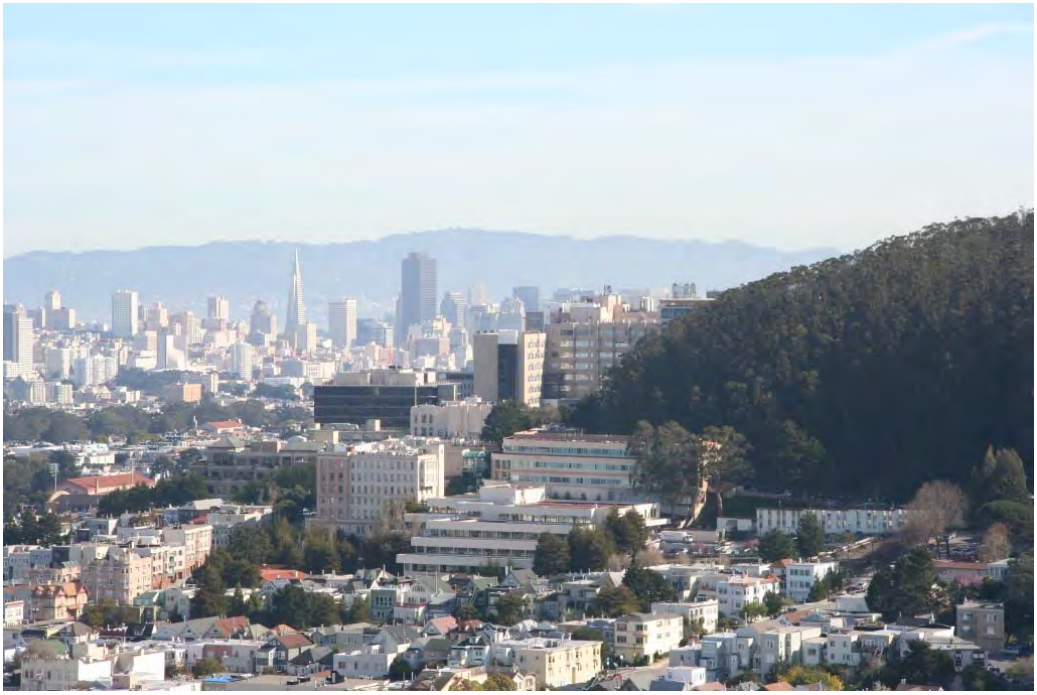
Most public views of the Reserve are from streets or other nearby public open spaces, such as Golden Gate Park or Grand View Park (near 14th Avenue and Noriega Street).

Source: UCSF

**Figure 4.1-2**
Looking South
From Lincoln Avenue / MLK Jr. Drive

Source: UCSF

**Figure 4.1-3**
Looking South
From Lincoln/3rd Avenues



Source: UCSF

**Figure 4.1-4**
Looking East
From Grand View Park

Source: UCSF

**Figure 4.1-5**
Looking East
From Kirkham Street/ 7th Avenue

Source: Denise Bradley

**Figure 4.1-6**
Looking East
From Lawton Street/ 8th Avenue

Source: UCSF

**Figure 4.1-7**
Looking West
From 17th/Clayton Streets

Source: UCSF

**Figure 4.1-8**
Looking West
From 17th/Shrader Streets

Source: UCSF

**Figure 4.1-9**
Looking Southwest
From Stanyan/Rivoli Streets

Source: Denise Bradley

**Figure 4.1-10**
Looking South from Willard Street

Source: Denise Bradley

**Figure 4.1-11**
Looking South
From Edgewood Avenue

Source: Denise Bradley

**Figure 4.1-12**
Looking Northeast
From Olympia Way/Clarendon Avenue

Source: UCSF

**Figure 4.1-13**
Looking North
From Clarendon Ave./Oak Park Drive

## Views from the Reserve

The potential for outward views from within the Reserve is great, given the elevation of the mountain and the abundance of natural and manmade features that could be viewed from the mountain, such as the Pacific Ocean to the west, the Marin Headlands and the Golden Gate Bridge to the north, and downtown San Francisco and the East Bay Hills to the east. However, due to the density of trees and vegetation in the Reserve, outward views from within the Reserve are very limited. Glimpses of views toward the north, west, and east are available from trails within the Reserve, but such views are obscured by trees and other vegetation. At the summit, trees are in abundance along its perimeter. The summit clearing formerly consisted of dense invasive French broom, but was converted in the early 2000s to a native plant garden (i.e., the Rotary Meadow) due to restoration efforts by the Rotary Club and the Mount Sutro Stewards. At present, there are no views or scenic vistas available from the summit that are not obscured by surrounding trees and vegetation (see Figures 4.1-14 to 4.1-16).

Source: Denise Bradley

**Figure 4.1-14**
Limited Views along Trails

Source: UCSF

**Figure 4.1-15**
Limited Views along Trails

Source: UCSF

**Figure 4.1-16**
The Summit

## 4.1.3 REGULATORY CONSIDERATIONS

### 4.1.3.1 UNIVERSITY GUIDELINES

While the University has adopted design guidelines for the development of buildings and associated landscaping, there are no formally adopted University guidelines concerning aesthetic values in the management of forests. As part of the development of the UCSF Mount Sutro Open Space Reserve Management Plan, the Parnassus Community Action Team (PCAT), a subgroup of the UCSF Community Advisory Group, identified planning principles for the Reserve. Among them is the principle to maintain the forest's scenic quality, and specifically to:

- maintain the overall forest character and visual backdrop of the hilltop Reserve
- avoid noticeable, sudden reductions in the forest cover as seen from off-site
- create small vistas of off-site features and forest openings, where desirable and practicable.

The *UCSF Mount Sutro Open Space Reserve Community Planning Process Summary Report* prepared in 2010 identified goals for management of the Reserve. Among them were goals for the aesthetics of the Reserve, which are also included in Chapter 3, Project Description, as Project Objectives:

- maintain a forested setting
- maintain attractive healthy trees
- improve visibility within the forest; and
- provide views beyond the forest

The report also discussed tree spacing: "It is UCSF's intention that the Reserve retain the look of a forested mountain following tree thinning because many trees will remain. UCSF is committed to tree spacing that will allow healthy trees to flourish, thus retaining a dense forested appearance."

### 4.1.3.2 SAN FRANCISCO GENERAL PLAN

The City and County of San Francisco's *San Francisco General Plan* includes policies that pertain to views and visual quality. While the University is not subject to these policies, it strives to be consistent with them to the extent feasible. The policies most relevant to the proposed project in relation to the topics of aesthetics and/or views are contained in the Urban Design Element of the *General Plan,* and are identified below. In addition, Map 1 in the Urban Design Element identifies important vista points to be protected.[2] Mount Sutro is not identified as an important vista point on this map.

**Principles for City Pattern**

- "Clearly visible open spaces act as orientation points, and convey information about the presence of recreation space to motorists and pedestrians.
- Where large parks occur at tops of hills, lowrise buildings surrounding them will preserve views from the park and maintain visibility of the park from other areas of the city.
- Highly visible open space presents a refreshing contrast to extensive urban development."

**Image and Character**

POLICY 1.1

"Recognize and protect major views in the city, with particular attention to those of open space and water.

- Views contribute immeasurably to the quality of the city and to the lives of its residents. Protection should be given to major views whenever it is feasible, with special attention to the characteristic views of open space and water that reflect the natural setting of the city and give a colorful and refreshing contrast to man's development.

[2] San Francisco General Plan, Urban Design Element: http://www.sf-planning.org/ftp/General_Plan/I5_Urban_Design.htm

- Overlooks and other viewpoints for appreciation of the city and its environs should be protected and supplemented, by limitation of buildings and other obstructions where necessary and by establishment of new viewpoints at key locations.
- Visibility of open spaces, especially those on hilltops, should be maintained and improved, in order to enhance the overall form of the city, contribute to the distinctiveness of districts and permit easy identification of recreational resources. The landscaping at such locations also provides a pleasant focus for views along streets."

**Natural Areas**

POLICY 2.1

"Preserve in their natural state the few remaining areas that have not been developed by man.

- Natural areas in the city that remain in their original state are irreplaceable and must not be further diminished. Significant development should not take place in these areas, and facilities necessary to aid in human enjoyment of them should not disturb their visual feeling or natural ecology. Accordingly, parking lots and service buildings should be confined to areas that are already developed, and access pathways should be designed to have a minimum effect upon the natural environment. Where possible, the interior of these natural areas should be out of sight of the developed city.
- Lands in public ownership, primarily those of the City and Federal governments, constitute the bulk of these natural areas. Coordinated programs for conservation of both land features and ecology should be carried out, with high priority given to such management functions. Where natural areas are in private ownership, either special incentives or public acquisition should be used to assure a similar degree of preservation."

## 4.1.4 SIGNIFICANCE STANDARDS AND METHODOLOGY

### Significance Criteria

The impacts of the proposed project on aesthetics would be considered significant if it would exceed the following standards of significance, in accordance with Appendix G of the State CEQA Guidelines and the UC CEQA Handbook:

- Have a substantial adverse effect on a scenic vista;
- Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a State scenic highway;
- Substantially degrade the existing visual character or quality of the site and its surroundings;
- Create a new source of substantial light or glare that would adversely affect day or nighttime views in the area; or

- Exceed the LRDP EIR significance standard by substantially reducing sunlight or significantly increasing shadows in public open space areas, or by increasing pedestrian-level wind speeds above the hazard level set forth in the San Francisco Planning Code.

### Issues Not Discussed Further

The Initial Study for the proposed project determined that the project's effect on scenic vistas, visual character or quality should be evaluated in the EIR. Accordingly, these topics will be analyzed in this section.

The Initial Study also determined that project effects on wind conditions would be less than significant and need not be analyzed in the EIR. However, as discussed in Section 4.0 Scope of Analyses, public comments raised during the Initial Study/EIR scoping comment period included concerns about wind impacts. Therefore, wind is analyzed in this EIR in Section 4.11, Wind.

The Initial Study for the proposed project found that implementation of the project would have no impact on scenic resources within a State scenic highway, and would have a less than significant impact with regards to creating shadows in public places. These issues are not discussed further in this section.

Additionally, the Initial Study for the proposed project found that the project would not create a new source of substantial light or glare that would adversely affect day or nighttime views in the area. During the Initial Study/EIR scoping period, a concern was raised by a local resident regarding the potential for vegetation removals to expose nearby residents to additional light and glare from the Aldea student housing complex. Additional light and glare exposure, if any, would not be substantial, as light sources within the housing complex are limited to the housing structures themselves -- much like other residential buildings throughout the City -- parking areas, and sidewalks. Such exposure would not be considered a significant environmental impact, and will not be discussed further in this section.

## 4.1.5 IMPACTS AND MITIGATION MEASURES

### Analysis Considerations

As discussed in the Project Description, the proposed project objectives with regard to aesthetics are:

- To maintain a forested setting
- To maintain attractive healthy trees
- To improve visibility within the forest
- To provide views beyond the forest

While the proposed project involves forest-thinning to an estimated average tree spacing of about 30 feet in most of the accessible areas of the Reserve and to an average tree spacing of about 60 feet within Demonstration Area #4, specific trees to be removed have not yet been identified. The

process of identification of specific trees to be removed would include consultation with UCSF's arborist and urban forester in consideration of the health and stability of the tree, distance from other trees, and aesthetic considerations, among other things. Because specific trees to be removed have not yet been identified, visual simulations of the proposed project would not be accurate and therefore are not provided in this analysis. Instead, photographs of actual results of similar forest management projects in the San Francisco Bay Area are presented below, to illustrate the visual effect of vegetation management actions in the manner proposed.

## Other Similar Vegetation Management Projects

The following are two examples of forest thinning projects in the Bay Area that involved eucalyptus forest-thinning and understory removal in a manner similar to the proposed project – removal of dead, unhealthy, or hazardous trees, removal of trees to an average tree spacing of about 30 feet, and understory removal. The aesthetic results of these projects are similar to the results the proposed project seeks to achieve – a forested setting, but one which is less dense than under current conditions, allowing for more light and air to be available for remaining vegetation.

### *Highway 1 "13 Curves", Point Reyes National Seashore*

**Before** **After**

Source: Ray Moritz

**Figure 4.1-17**
Highway 1 "13 Curves" Project

The Highway 1 "13 Curves" project in the Point Reyes National Seashore was undertaken to reduce the fuel load and to improve the health of the forest. The project involved the removal of ground and ladder fuels, the removal of saplings less than 10 inches in diameter, the removal of subordinate trunks of multi-trunked trees, and the clearance of loose bark and debris up to 10 feet from the ground. As can be seen in Figure 4.1-17, the result was a less dense forest, but one that maintained the pleasing aesthetic qualities of a forest while allowing light and air to reach the forest floor.

### *Camino Del Canyon, near Muir Woods National Monument*

**Before**

**After**

Source: Ray Moritz

**Figure 4.1-18**
Camino Del Canyon Project

The Camino Del Canyon project near Muir Woods National Monument was similarly undertaken to reduce the fuel load and improve the health of the forest. The project involved the removal of ground and ladder fuels, removal of saplings under 10 inches in diameter, removal of loose bark and debris up to 10 feet from ground level, and raising crowns to 10 feet or more above ground. About 60% of the eucalyptus stems were removed. As reflected in Figure 4.1-18, the results were a more open, accessible forest. The essential visual and aesthetic qualities of the forest however, remained intact.

## Project Impacts and Mitigation Measures

**Impact AES-1: The proposed project could have a substantial adverse effect on a scenic vista. (Less than Significant)**

A scenic vista is an expansive view of a highly-valued landscape for the benefit of the general public. As discussed in section 4.1.2, Environmental Setting, from long-range vantage points the Reserve may be viewed as part of a network of hills and open spaces across the central/western portion of San Francisco along with nearby Golden Gate Park, Twin Peaks, Mount Davidson, Grand View Park, and other public open spaces. From mid- and short-range vantage points, the Reserve is dominant and stands out in the landscape, particularly when viewed from the north, east and west. The Reserve provides a dramatic visual contrast from the man-made structures that surround it, and therefore is an integral part of the aesthetic qualities of the central/western portion of San Francisco. However, the Reserve and its surroundings are not part of a distinct scenic vista. The project would not obstruct, significantly alter, or otherwise have a substantial adverse effect on a scenic vista. Therefore, project effects on a scenic vista would be less than significant.

Effects on views from private residences are not considered significant under CEQA. Views of the Reserve from private residences may be altered in that the Reserve will have diminished

shrub and grass cover and tree density. However, the changes to the visual quality of the Reserve would not be substantially degraded as discussed below.

Select trees would be removed to create views from the Reserve. This would be a beneficial impact with regard to views and scenic vistas.

**Mitigation Measure**: None required

**Impact AES-2: The proposed project could substantially degrade the existing visual character or quality of the site and its surroundings. (Less than Significant)**

Most Demonstration Project activities would have little effect on the visual qualities of the Reserve when viewed from off-site. Demonstration Project areas comprise about 7.5 acres of the 61-acre Reserve, and are located primarily within the interior of the Reserve. However, visual changes could be noticeable at the southern tip of the Demonstration Project 1 South Ridge Area, which is located in close proximity to the southern border of the campus at Christopher and Crestmont Drives. This location could be visible from points south of the Reserve. Persons viewing this section of the Reserve may notice fewer trees at this location and a less dense forest, particularly during initial implementation. Over time, as remaining trees have more access to light, water and nutrients, remaining trees are expected to become healthier and new branch/canopy growth would be expected. Nonetheless, the project would result in reduced vegetation density compared to existing conditions.

Given the close proximity of Edgewood Avenue homes to the Demonstration Project 2 Edgewood Avenue Area, residents in this area may notice a less dense forest. However, the visual changes would not be significant given the intervening structures and parking lots that separate the Edgewood Avenue homes from the Demonstration Project 2 Edgewood Avenue area.

The Demonstration Project 3 North Side of Summit area would involve minimal visual changes, as select trees would be removed only as needed to prevent shading of the existing Nootka reed grass area and to maintain a clear view corridor to the northeast. These changes are not expected to be noticeable from outside the Reserve, and would not constitute a significant adverse impact on visual quality.

Within the Demonstration Project 4 East Bowl Corridor, tree thinning is proposed to an average spacing of about 60 feet between trunks, rather than an average spacing of 30 feet proposed elsewhere in the Reserve. At this location, a slightly more dramatic change may be noticeable given the 60-foot spacing between trees. When viewed from points east of the Reserve, the East Bowl Corridor would be noticeably less dense and the forest floor may be visible. Residents close to this portion of the Reserve may notice less shading and more access to light that comes with decreased vegetation density. However, given the remainder of the forest as a backdrop, the change would not be considered a substantial degradation of the existing visual character or quality of the site and its surroundings.

Continued vegetation management activities throughout the remainder of the Reserve, including tree-thinning, understory removal, and new trails would have some effect on the visual qualities of the Reserve when viewed from off-site. As demonstrated in the real-world examples of tree-thinning projects presented above, the proposed project would result in a more visually open, less dense forest. As indicated above, the greatest visual change would occur during the initial implementation when understory and tree thinning are first undertaken. Over time, as remaining trees have more access to light, water and nutrients, new branch and canopy growth would materialize, and the visual effect of vegetation management activities would be less dramatic. In addition, continued vegetation management would be expected to be performed in phases, depending on the availability of funding, and would not be implemented at once. Following continued vegetation management activities, the Reserve would retain its forested appearance.

Viewed from within the interior of the Reserve, the forest would appear more airy and penetrable, as more light would reach the forest floor. This could be perceived by some as a beneficial impact with regard to visual quality.

For the reasons stated above, the proposed project would not substantially degrade the existing visual character or quality of the site and its surroundings. Therefore, impacts on aesthetics and visual quality are less than significant.

**Impact AES-3: Proposed project activities could have a substantial cumulative adverse effect on a scenic vista, or substantially degrade the existing visual character or quality of the site and its surroundings. (Less than Significant)**

The City and County of San Francisco proposes to implement various vegetation management actions within the Interior Greenbelt Natural Area as part of the Significant Naturals Resource Areas Management Plan (SNRAMP). The 12-acre Interior Greenbelt Natural Area is located adjacent to the Reserve on its east side. Proposed vegetation management activities include the removal of approximately 140 eucalyptus trees of an approximate overall stand of 5,800 trees in the Interior Greenbelt. The Draft EIR for the SNRAMP has concluded that visual quality impacts are less than significant.

The combined aesthetic effect of the proposed project activities within the Reserve and SNRAMP activities within the Interior Greenbelt would not result in a significant impact on scenic vistas and visual quality. No scenic vistas would be obstructed or otherwise substantially affected in an adverse manner. Given the relatively small size of the 12-acre Interior Greenbelt parcel, about one-fifth the size of the 61-acre Reserve, and the nominal amount of tree thinning proposed in the Interior Greenbelt, visual quality impacts would not be cumulatively considerable.

No other natural areas are in close enough proximity to the proposed project to create a cumulative visual quality impact.

**Mitigation Measure**: None required

## 4.1.6 REFERENCES

City and County of San Francisco, Recreation and Parks Department, *Significant Natural Resource Areas Management Plan, Final Draft*, February 2006

# 4.2 AIR QUALITY

This section addresses the impacts of the proposed project on ambient air quality and the exposure of people, especially sensitive individuals, to unhealthful pollutant concentrations of the type and quantity of emissions that would be generated by the implementation and operation of the proposed project. The analysis of criteria pollutant emissions focuses on whether the project would cause an exceedance of a state ambient air quality standard or an exceedance of a threshold set forth by the Bay Area Air Quality Management District (BAAQMD). The impacts associated with the proposed project are compared with thresholds of significance under CEQA.

No comments related to air quality were received during the Initial Study/EIR scoping process.

## 4.2.1 ENVIRONMENTAL SETTING

### Background

The proposed project is located in the City and County of San Francisco, which is included in the San Francisco Bay Area Air Basin (SFBAAB). The Bay Area Air Quality Management District (BAAQMD) has jurisdiction over air quality within the Air Basin. The Bay Area is classified as nonattainment for state and national ozone standards and for state particulate matter (PM10, PM2.5) standards.[1] The proposed project does not include new operational sources.

## 4.2.2 REGULATORY CONSIDERATIONS

### Federal

The federal Clean Air Act (CAA) requires the U.S. Environmental Protection Agency (US EPA) to define national ambient air quality standards (national standards) to protect U.S. public health and welfare. "Criteria" air pollutants are potentially harmful emitted compounds that have established national standards to protect sensitive receptors identified in the CAA, including the elderly, young children, people with pre-existing illness, and individuals performing strenuous work or exercise. Criteria pollutants with associated national standards are ozone, carbon monoxide (CO), nitrogen dioxide (NOX), sulfur dioxide (SO2), lead, and respirable particulate matter (PM10 and PM2.5, particulates with diameters less than 10 and 2.5 microns, respectively).

California has adopted state standards for some pollutants for which there are no corresponding national standards and has implemented more stringent air quality standards for the criteria pollutants. National and state standards are presented in Table 4.2-1, as reported by the BAAQMD. The US EPA, pursuant to the CAA Amendments of 1990, required each state to identify areas (air basins or portions thereof) within its borders as either "attainment" or "nonattainment" for each criteria air pollutant, based on whether the national standards had been met. The San Francisco Bay Area is in attainment or unclassified for all federal criteria pollutants,

[1] http://hank.baaqmd.gov/pln/air_quality/ambient_air_quality.htm

except for ozone. "Unclassified" is defined in the Clean Air Act Amendments as any area that cannot be classified, on the basis of available information, as meeting or not meeting the national primary and secondary air quality standard for the specified pollutant.

## State

The California Air Resources Board (CARB) manages air quality, regulates mobile emission sources, and oversees the activities of county air pollution control districts and regional air quality management districts. State standards are stricter than national standards, as depicted in Table 4.2-1. Similar to the federal Clean Air Act, the California Clean Air Act designates air basins in the state as either attainment or nonattainment based on whether the specified area meets state standards.

In July 2007, the CARB adopted an off-road diesel rule to reduce PM emissions, including engines used in urban construction equipment. On June 2, 2010, the U.S. EPA established a new 1-hour SO2 standard.

## Regional and Local

### *Bay Area Air Quality Management District*

The proposed project is located in the City and County of San Francisco, which is included in the San Francisco Bay Area Air Basin (SFBAAB). The Bay Area Air Quality Management District (BAAQMD) has jurisdiction over air quality within the Air Basin. In June 2010, the BAAQMD published significance thresholds in the *BAAQMD CEQA Air Quality Guidelines* (hereinafter BAAQMD CEQA Guidelines) to assist lead agencies in evaluating the significance of a project's individual and cumulative impact on local air quality. The Guidelines were further updated in May 2011. On March 5, 2012 the Alameda County Superior Court issued a judgment finding that the Air District had failed to comply with CEQA when it adopted the thresholds. The court did not determine whether the thresholds were valid, but found that the adoption of the thresholds was a project under CEQA. The court issued a writ of mandate ordering the District to set aside the thresholds and cease dissemination of them until the Air District had complied with CEQA (BAAQMD 2012). At present, the thresholds are not being recommended for use by the BAAQMD.[2]

Lead agencies determine appropriate air quality thresholds of significance based on substantial evidence in the record, although lead agencies may rely on the Air District's CEQA Guidelines (updated May 2011) for assistance in calculating air pollution emissions, obtaining information regarding the health impacts of air pollutants, and identifying potential mitigation measures. Lead agencies may continue to rely on the Air District's 1999 Thresholds of Significance and they may continue to make determinations regarding the significance of an individual project's air quality impacts based on the substantial evidence in the record for that project.

[2] http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES.aspx

**Table 4.2-1**
**National and State Air Quality Standards**

| Pollutant | Averaging Time | California Standards[1] | | National Standards[2] | |
|---|---|---|---|---|---|
| | | Concentration | Attainment Status | Concentration[3] | Attainment Status |
| Ozone | 8 Hour | 0.070 ppm (137µg/m$^3$) | N[9] | 0.075 ppm | N[4] |
| | 1 Hour | 0.09 ppm (180 µg/m$^3$) | N | | See footnote # 5 |
| Carbon Monoxide | 8 Hour | 9.0 ppm (10 mg/m$^3$) | A | 9 ppm (10 mg/m$^3$) | A[6] |
| | 1 Hour | 20 ppm (23 mg/m$^3$) | A | 35 ppm (40 mg/m$^3$) | A |
| Nitrogen Dioxide | 1 Hour | 0.18 ppm (339 µg/m$^3$) | A | 0.100 ppm (see footnote 11) | U |
| | Annual Arithmetic Mean | 0.030 ppm (57 µg/m$^3$) | | 0.053 ppm (100 µg/m$^3$) | A |
| Sulfur Dioxide (See Footnote #12) | 24 Hour | 0.04 ppm (105 µg/m$^3$) | A | 0.14 ppm (365 µg/m$^3$) | A |
| | 1 Hour | 0.25 ppm (655 µg/m$^3$) | A | 0.075 ppm (196 µg/m$^3$) | A |
| | Annual Arithmetic Mean | | | 0.030 ppm (80 µg/m$^3$) | A |
| Particulate Matter (PM10) | Annual Arithmetic Mean | 20 µg/m$^3$ | N[7] | | |
| | 24 Hour | 50 µg/m$^3$ | N | 150 µg/m$^3$ | U |
| Particulate Matter - Fine (PM2.5) | Annual Arithmetic Mean | 12 µg/m$^3$ | N[7] | 15 µg/m$^3$ | A |
| | 24 Hour | | | 35 µg/m$^3$ See Footnote 10 | N |
| Sulfates | 24 Hour | 25 µg/m$^3$ | A | | |
| Lead (See Footnote 13) | 30 day Average | 1.5 µg/m$^3$ | | - | A |
| | Calendar Quarter | - | | 1.5 µg/m$^3$ | A |
| | Rolling 3 Month Average[14] | - | | 0.15 µg/m$^3$ | (See Footnote 14) |
| Hydrogen Sulfide | 1 Hour | 0.03 ppm (42 µg/m$^3$ | U | | |
| Vinyl Chloride (chloroethene) | 24 Hour | 0.010 ppm (26 µg/m$^3$ | No information available | | |
| Visibility Reducing particles | 8 Hour (10:00 to 18:00 PST) | See Footnote 8 | U | | |
| **A=Attainment N=Nonattainment U=Unclassified** | | | | | |
| mg/m$^3$=milligrams per cubic meter | | ppm=parts per million | | µg/m$^3$=micrograms per cubic meter | |

## 4.2.3 EQUIPMENT OPERATIONS

The project does not include new equipment requiring BAAQMD permits or operational sources.

Vegetation management actions are proposed to occur throughout the Reserve over several years. For the purposes of estimating a conservative upper bound on air emissions this analysis assumes equipment associated with 15 acres of land to undergo management activities during any given year.

To accomplish the proposed tree thinning, UCSF would employ a single Brontosaurus mower, a chipper, and a yarder at any given time. Off-haul heavy trucks would be required to remove excess material and employees of the company retained to do the vegetation management would commute to the site.

Vegetation management-related effects on air quality relate strictly to direct and indirect impacts that could occur during management activities, such as the removal of dead, dying, unhealthy or hazardous trees. Implementation-related GHG emissions were analyzed using the most recent version of the URBEMIS model (9.2.4) that is recommended by the BAAQMD. URBEMIS uses the CARB OFFROAD 2007 model for calculating emissions from off road equipment.

There would be no new emission sources added; therefore, operation-related effects on air quality are not analyzed further. For the purposes of the document, it was assumed that any maintenance activities planned following the proposed project would be minimal and would not raise emissions beyond a significant level.

## 4.2.4 SIGNIFICANCE STANDARDS AND ANALYSIS METHODOLOGY

The Bay Area Air Quality Management District (BAAQMD), the regional air quality board presiding over San Francisco, has jurisdiction over Air Quality.

The University has examined the information in the BAAQMD CEQA Guidelines and other information and determined that it will use the significance thresholds provided in the BAAQMD CEQA Guidelines to evaluate the air quality impacts that could potentially result from the project's criteria pollutant and toxic air contaminants (TAC) emissions. Table 4.2-2, CEQA Significance Thresholds – BAAQMD, below presents the significance thresholds for criteria pollutants contained in the BAAQMD CEQA Guidelines.

**Table 4.2-2**
**CEQA Significance Thresholds – BAAQMD**

| Pollutant | Construction | Operation |
|---|---|---|
| Reactive Organic Gases (ROG) | 54 lb/day | 54 lb/day or 10 tons/yr |
| Nitrogen Oxides ($NO_x$) | 54 lb/day | 54 lb/day or 10 tons/yr |
| Respirable Particulate Matter (PM10) | 82 lb/day (exhaust) | 82 lb/day or 15 tons/yr |
| Fine Particulate Matter (PM2.5) | 54 lb/day (exhaust) | 54 lb/day or 10 tons/yr |
| Fugitive Dust (PM10/PM2.5) | Best Management Practices | — |
| Carbon Monoxide (CO) | — | 9 ppm (8-hour) or 20 ppm (1-hour) |

*Source: Bay Area Air Quality Management District, California Environmental Quality Act Air Quality Guidelines, (2011) 2-1.*

The average daily emissions thresholds in Table 4.2-2 are based on emissions of 10 tons per year for ROG, NOx, and PM2.5 and 15 tons per year for PM10. These values were established by the California Air Resources Board as the thresholds at which a facility becomes subject to the California Air Toxic "Hot Spots" Information and Assessment Act, which was passed in 1987. The program was amended in 2007 to include diesel PM. Consequently, these values are applicable to all facilities emitting criteria pollutants in California, and similar thresholds are in use in many other air districts in California. Based on the above substantial evidence, the thresholds shown in Table 4.2-2 will be used to evaluate the impacts of the proposed project.

## Significance Criteria

According to the amended Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment if it would:

- Conflict with or obstruct implementation of the applicable air quality plan
- Violate any air quality standard or contribute substantially to an existing or projected air quality violation (e.g., induce mobile source carbon monoxide (CO) emissions that would cause a violation of the CO ambient air quality standard)
- Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors
- Expose sensitive receptors to substantial pollutant concentrations
- Create objectionable odors affecting a substantial number of people

- Exceed the applicable LRDP EIR standard of significance by exposing receptors to toxic air contaminant emissions that (1) result in a cancer risk greater than 10 cancer cases per 1 million people exposed in a lifetime; or (2) for acute or chronic effects, result in concentrations of toxic air contaminant emissions with a Hazard Index of 1.0 or greater.

## Issues Not Discussed Further

As discussed in the Initial Study for the proposed project, creating objectionable odors affecting a substantial number of people, odorous substances are regulated under BAAQMD Regulation 7. This regulation prohibits the emission of odorous compounds which remain odorous after dilution with a specified quantity of odor-free air. Management activities, including the use of heavy equipment, would not involve odorous substances that exceed this regulation. As the project would not result in a substantial adverse effect on odors, this topic will not be evaluated further in the EIR.

## Mitigation Measures Included in the Proposed Project

The following mitigation measure was adopted by The Regents in connection with certification of the LRDP EIR, as amended by the Medical Center at Mission Bay EIR, certified by The Regents in September 2008, and is included as part of the proposed project. The analysis presented below evaluates environmental impacts that would result from project implementation following the application of this mitigation measure:

**Mitigation Measure MCMB2.1 (from the Medical Center at Mission Bay EIR):** To further mitigate less than significant project-level impacts, additional measures related to the 2007 CARB off-road diesel rule on equipment exhaust emissions from construction equipment shall be required in UCSF construction contracts to comply with the following measures:

- Prohibit the use of conventional cutback asphalt for paving to restrict the maximum VOC content of asphalt emulsion. Diesel portable generators less than 50 horsepower shall not be allowed at the construction site, except for those used by welders.3

- All diesel-fueled engines used for on- and off-site construction activities shall be fueled only with ultralow sulfur diesel, which contains no more than 15 ppm sulfur.

- All construction diesel engines used for on- and off-site activities that have a rating of 100 horsepower (hp) or more shall meet, at a minimum, the Tier 2 California Emission Standards for Off-Road Compression-Ignition Engines as specified in California Code of Regulations, Title 13, section 2423(b)(1) unless it is certified by the construction contractor that such engine is not available for a particular item of equipment. In the event a Tier 2 engine is not available for any off-road engine larger than 100 hp, that engine shall be a Tier 1 engine. In the event a Tier 1 or Tier 2 engine is not available for any off-road engine larger than 100 hp, that engine shall be equipped with a CARB Level 3-verified diesel emission control device (e.g., catalyzed diesel particulate filter), unless the engine

[3] Welding trucks have self-contained units with generators less than 50 horsepower.

manufacturer or the construction contractor certifies that the use of such devices is not practical for specific engine types. In the event that a CARB Level 3 verified diesel emission control device is not practical for the specific engine type, then the engine shall be equipped with a CARB Level 1- or 2-verified control device (e.g., diesel oxidation catalyst), unless the engine manufacturer or the construction contractor certifies that such devices are not available for the engine in question. For purposes of this condition, the use of such devices is "not practical" if, among other reasons:

1. The construction equipment is intended to be on site for 10 days or less.

2. The use of the diesel emission control device is excessively reducing normal availability of the construction equipment due to increased downtime for maintenance, and/or reduced power output due to an excessive increase in backpressure.

3. The diesel emission control device is causing or is reasonably expected to cause significant engine damage.

In the event that the use of a diesel emission control device is to be terminated, the construction contractor shall be required to inform the UCSF project manager within 10 days prior to such termination.

- Construction equipment shall be properly tuned and maintained in accordance with manufacturers' specifications.

- Best management construction practices shall be used to avoid (or limit) unnecessary emissions (e.g., trucks and vehicles in loading and unloading queues would turn their engines off when not in use, and to the extent practical, all diesel heavy construction equipment shall not remain running at idle for more than 5 minutes)

- Use alternative fueled equipment when feasible (such as ULSD, CNG, biodiesel, water emulsion fuel, and electric). The construction contracts shall require each contractor and subcontractor to consider this measure and adopt it for their work unless they can demonstrate to UCSF the inapplicability or infeasibility of the measure to their specific work, or can provide mitigation measures with equivalent or better effectiveness. This information shall be reported as part of the Mitigation Monitoring Reporting and Compliance Program.

- Use on-site power when feasible to reduce reliance on portable generators. The construction contracts shall require each contractor and subcontractor to consider this measure and adopt it for their work unless they can demonstrate to UCSF the inapplicability or infeasibility of the measure to their specific work, or can provide mitigation measures with equivalent or better effectiveness. This information shall be reported as part of the Mitigation Monitoring Reporting and Compliance Program.

## 4.2.5 IMPACTS AND MITIGATION MEASURES

**Impact AIR-1: The proposed project could conflict with or obstruct implementation of the applicable air quality plan. (Less than Significant)**

The project site is within the SFBAAB, which is under the jurisdiction of the BAAQMD, the governing authority for air quality planning in the region. A project can be considered consistent with air quality plans if it: (1) would not result in significant and unavoidable air quality impacts, (2) will incorporate all feasible air quality plan control measures, and (3) would not cause the disruption, delay or hinder the implementation of any air quality plan control measure.

Projects that do not result in emissions of air pollutants that exceed the thresholds would not be considered as having a significant impact on the attainment of air quality goals and would therefore be consistent with the current air quality plan.

Construction activities would result in emissions of air pollutants. These emissions were modeled for the revised project using URBEMIS2007, a land use and construction model used to calculate emissions generated from construction and operation of new development projects. Default values provided by URBEMIS2007 were used for construction of the proposed project, which was estimated to take place over approximately 2.5 months per year beginning in 2013 and continuing through 2015. The estimated maximum construction emissions are shown in Table 4.2-3, Estimated Construction Emissions – URBEMIS2007. Emission rates for respirable particulate matter (PM10) and fine particulate matter (PM2.5) include both vehicle exhaust and fugitive dust emissions.

**Table 4.2-3**
**Estimated Construction Emissions – URBEMIS2007**

| Pollutant | Maximum Emission Rate (lbs. per day) | | | Threshold (lbs. per day) |
|---|---|---|---|---|
| | 2013 | 2014 | 2015 | |
| ROG | 2.58 | 2.44 | 2.28 | 54 |
| NOx | 20.61 | 19.12 | 17.54 | 54 |
| PM10 (Exhaust and Fugitive Dust) | 10.23 | 10.22 | 10.21 | 82 |
| PM2.5 (Exhaust and Fugitive Dust) | 2.23 | 2.23 | 2.22 | 54 |

*Emissions calculations are provided in **Appendix B**.*

As shown in Table 4.2-3 above, construction of the proposed project would not result in emissions that would exceed any of the significance thresholds for construction air emissions. In addition, the project includes LRDP Mitigation Measure MCMB.2-1 and will implement

BAAQMD basic construction mitigation measures to further reduce construction-phase emissions.

The project does not include new equipment requiring BAAQMD permits or operational sources. Nonetheless, the proposed project would result in minor emissions of air pollutants that were also modeled using URBEMIS2007. Default values provided by URBEMIS2007 were used for operation of the project. Both area and mobile sources were modeled using default assumptions in URBEMIS. Table 4.2-4 Estimated Operational Emissions, identifies the maximum daily emissions for each pollutant during project operation.

**Table 4.2-4**
**Estimated Operational Emissions**

| Emissions Source | Emissions in Pounds per Day | | | | | |
|---|---|---|---|---|---|---|
| | ROG | NOx | CO | SOx | PM10 | PM2.5 |
| **Summertime Emissions**[1] | | | | | | |
| Area Sources | 0.12 | 0.02 | 1.55 | 0.00 | 0.01 | 0.01 |
| Mobile Sources | 0.23 | 0.11 | 1.13 | 0.00 | 0.23 | 0.04 |
| Summertime Totals | 0.35 | 0.13 | 2.68 | 0.00 | 0.24 | 0.05 |
| Significance Thresholds | 54 | 54 | — | — | 82 | 54 |
| Exceeds Threshold? | NO | NO | — | — | NO | NO |
| **Wintertime Emissions**[2] | | | | | | |
| Area Sources | 0.00 | — | — | — | — | — |
| Mobile Sources | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 |
| Wintertime Totals | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 |
| Significance Thresholds | 54 | 54 | — | — | 82 | 54 |
| Exceeds Threshold? | NO | NO | — | — | NO | NO |

*Emissions calculations are provided in **Appendix B**. Values above for highest year - 2013.*
*Totals in table may not appear to add exactly due to rounding in the computer model calculations.*
[1] *"Summertime Emissions" are representative of the conditions that may occur during the ozone season (May 1 to October 31).*
[2] *"Wintertime Emissions" are representative of the conditions that may occur during the balance of the year (Nov 1 to April 30).*

As shown above, minor operational emissions associated with the day-to-day activities at the proposed building would not exceed any of the operational thresholds of significance. Projects that generate emissions below the regional thresholds of significance would not be considered to contribute a substantial amount of air pollutants. Therefore, operational emissions would be considered to have a less than significant impact, and the project would not contribute substantially to the existing nonattainment status of the SFAAB for ozone, PM10, and PM2.5.

Since operation of the proposed project would not result in significant additional air pollutant emissions, the proposed project would not hinder, disrupt, or delay the implementation of any air quality control measures. The proposed project would also comply with all applicable rules, regulations, and recommended actions. Therefore, the proposed project is consistent with the applicable air quality plans. No further analysis is required.

**Mitigation:** None required.

**Impact AIR-2: The proposed project could violate an air quality standard or contribute substantially to an existing or projected air quality violation (e.g., induce mobile source carbon monoxide (CO) emissions that would cause a violation of the CO ambient air quality standard. (Less than Significant)**

Traffic congested roadways and intersections have the potential to generate localized high levels of CO. Localized areas where ambient concentrations exceed state and/or federal standards are termed CO "hotspots." Such hot spots are defined as locations where the ambient CO concentrations exceed the state or federal ambient air quality standards for CO. CO is produced in greatest quantities from vehicle combustion and is usually concentrated at or near ground level because it does not readily disperse into the atmosphere. Areas of vehicle congestion have the potential to create CO hotspots that exceed the state or federal ambient air quality standards for CO.

The BAAQMD CEQA Guidelines include screening criteria for CO based on the number of vehicle trips a proposed project would add to local roadways as well as consistency with the applicable congestion management plan. Regarding the number of trips added to local roadways, the BAAQMD CEQA Guidelines state that a project that would not increase traffic volumes to more than 44,000 vehicles per hour in affected intersections would not have a significant impact on local CO concentrations. The proposed project would add approximately 30 trips per day. The busiest roadway near the project carries just over 25,000 vehicles per day, for a worst-case total of 25,030 vehicles per day. As the total trips per day are less than the screening value of 44,000 vehicles per hour, the impact of the proposed project related to CO would be less than significant.

**Mitigation:** None required.

**Impact AIR-3: The proposed project could result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors. (Less than Significant)**

The San Francisco Bay Area Air Basin is in non-attainment of state and federal standards for ozone, and in non-attainment of the state standards for PM10 and PM2.5. Ozone is formed in the atmosphere via chemical reactions of ROG and NO2 in sunlight. Emissions of ROG are generated from combustion engines, such as those used in motor vehicles and construction equipment, and from architectural coatings and the use of solvents and cleaners. Emissions of NO2 are generated principally from combustion engines such as those used in motor vehicles and construction equipment. Emissions of PM10 and PM2.5 are generated by both construction activities, such as grading, as well as by motor vehicles traveling over paved and unpaved surfaces.

The BAAQMD CEQA Guidelines state that criteria pollutant emissions thresholds were developed such that emissions from an individual project that exceed the thresholds would be

cumulatively considerable. As emissions from this project are below the threshold for all pollutants during both construction and operation, the project would not result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality. As a result, no further analysis is required and no additional mitigation measures are required beyond the basic construction mitigation measures previously discussed. This impact is considered less than significant.

**Mitigation:** None required.

**Impact AIR-4: The proposed project could expose sensitive receptors to substantial pollutant concentrations. (Less than Significant)**

The BAAQMD recommends the implementation of *Basic Construction Mitigation Measures* and applicable air toxic control measures (ATCM) for all construction. The university implements these measures on all projects where applicable. Mitigation Measure MCMB.2-1 is included as part of the proposed project. With this mitigation measure air quality impacts related to construction activities would be less than significant.

**Mitigation:** None required.

**Impact AIR-5: Exceed the applicable LRDP EIR standard of significance by exposing receptors to toxic air contaminant emissions that (1) result in a cancer risk greater than 10 cancer cases per 1 million people exposed in a lifetime; or (2) for acute or chronic effects, result in concentrations of toxic air contaminant emissions with a Hazard Index of 1.0 or greater. (Less than Significant)**

Toxic air contaminants (TACs) contribute to local health risks, including increased risk of cancer. Sources of TACs and PM2.5 include motor vehicles, diesel backup generators, industrial processes, and others. The BAAQMD recommended that proposed projects assess the health risk impacts of new TAC sources associated with a proposed project on existing local sensitive receptors as well as risks for any new sensitive receptors associated with a proposed project from existing and new sources. The proposed project is a vegetation management project, which in and of itself would not produce any TAC's as defined by the BAAQMD.

TAC emissions in the Bay Area have been declining and will continue to decline due to adopted legislation requiring implementation of new technologies to reduce air toxics, particularly from diesel-fueled engines. Additionally, air toxics impacts generally are localized around emission sources, so impacts do not generally cumulate at a substantial distance. The project site should experience reductions in background TAC levels in future years reflective of the anticipated overall regional reductions in TAC levels.

However, the proposed project would include minor sources of TACs during both construction and operation. The primary sources associated with the proposed project are diesel-fueled construction equipment. The project-related traffic would not result in an increase in large diesel-fueled vehicles such as trucks, and so would not be a significant source of diesel particulate

matter. Construction would result in emissions of TACs, primarily as diesel particulate matter (DPM) from construction equipment. The University has incorporated mitigation measure MCMB.2-1 above to reduce TAC's to the minimal feasible level.

Cumulative TAC emissions would be considered less than significant given anticipated reductions in overall TAC emissions in the Bay Area.

**Mitigation:** None required.

## 4.2.6 REFERENCES

BAAQMD. 1999 / 2010. CEQA Guidelines
http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES.aspx

# 4.3 BIOLOGICAL RESOURCES

## 4.3.1 INTRODUCTION

This section discusses the existing biological resources and evaluates the potential impacts on biological resources from the implementation of proposed management activities. The section also provides discussion of the applicable federal, state, regional, and local agencies that regulate biological resources. The impacts associated with the proposed project are compared with the thresholds of significance adopted by the California Environmental Quality Act (CEQA). A biological resources report[1] was conducted by LSA Associates, Inc., and information from the report is summarized in this section. The biological resources report is included in Appendix C of this EIR.

Comments related to biological resources received during the Initial Study/EIR scoping process included concerns about the following:

- Impacts on wildlife and wildlife habitat
- Impacts of conversion planting

## 4.3.2 ENVIRONMENTAL SETTING

### Background

The approximately 61- acre Reserve is located at UCSF Parnassus Campus, adjacent to and including Mount Sutro. The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and other plants and replacement with native species.) Vegetation management actions are proposed to occur throughout the Reserve over many years and would be phased beginning with four demonstration projects that were crafted during the community planning process. The first three demonstration projects are planned for implementation following the completion of environmental review and project approval. The fourth demonstrations project would be implemented approximately one year after the first three demonstration projects. The proposed management activities and the detailed description of the demonstration projects are as discussed in Chapter 3, Proposed Project.

In addition, the following Best Management Practices (BMP's) will be incorporated as part of the project for treatment of the demonstration areas, continued implementation over the entire Reserve, and ongoing maintenance activities.

[1] LSA Associates, Inc., Biological Resources Report, Mount Sutro Open Space Reserve, San Francisco CA, September 27, 2011

1. Disturbance to existing grades and vegetation will be limited to the actual treatment or restoration areas and necessary access routes. Placement of all trails, staging areas and other facilities will avoid and limit disturbance to existing native plants to the maximum extent practicable, with the exception of poison oak. Where possible, existing ingress or egress points will be used and contours of the work area will be returned to pre-construction conditions.
2. Disturbed soils resulting from treatment activities will be stabilized prior to the rainy season by spreading woodchips or shreds or other mulch materials over the bare ground.
3. Straw wattles, silt fencing, straw bales, or similar sediment control measures will be installed on contours along the lower edge of the treatment areas to prevent excess sediment from entering the watershed, if deemed necessary.
4. To avoid attracting predators, food-related trash will be disposed in closed containers and regularly removed from the work areas.
5. All construction material, wastes, debris, sediments, rubbish, vegetation, trash, fencing, etc., will be removed from the site upon completion of treatments and transported to an authorized disposal area, as appropriate, and per all federal, State and local laws and regulation.
6. All construction-related holes will be covered to prevent entrapment of native amphibians, reptiles and small mammals.

#### 4.3.2.1 VEGETATION

The majority of vegetation within the Reserve consists of dense eucalyptus forest that is described as Eucalyptus Groves (*Eucalyptus* Semi-Natural Woodland Stands)[2] with dense understory of English ivy (*Hedera helix*) and Himalayan Blackberry Bramble (*Rubus armeniacus* Semi-Natural Stands). Throughout the Reserve are remnants of Coastal Brambles, a native vegetation that is scattered. The summit clearing (i.e., Rotary Native Plant Garden) formerly consisted of dense invasive French broom, but was converted to Coyote Brush Scrub due to restoration efforts by the Mount Sutro Stewards in the early 2000s. Each vegetation type, including non-vascular flora (i.e., lichens and mosses) are briefly described below.

- **Eucalyptus Groves** (*Eucalyptus* Semi-Natural Woodland Stands). Eucalyptus Groves are dominated by one of at least nine eucalyptus species known to occur in California. The eucalyptus forest that covers the majority of the Reserves is primarily a monotypic stand dominated by blue gum eucalyptus (*Eucalyptus globulus*) with an average trunk size ranging from 24-42 inches in basal diameter. The largest trees range from 150 to 200 feet in height. Branching in most of these trees occurs at 50-75 feet above the ground, providing an open canopy. Larger blue gum trees are widely spaced throughout the forest, suggesting that they were originally planted in the late 1880s. Smaller blue gum trees that are approximately 30 to 50 feet tall are more closely spaced and are more

[2] Both the common and scientific names are provided throughout this section. Common name appears first and the scientific name follows in italic and parentheses.

abundant than the larger trees. Monterey cypress and Monterey pine are also scattered throughout the forest, and several large coast redwoods have been planted near the main UCSF campus on the north side of the Reserve. These trees occasionally reach heights and basal diameters similar to the blue gum.

The middle canopy of the forest is comprised of blackwood acacia (*Acacia melanoxylon*), flowering plums (*Prunus* sp.), red elderberry (*Sambucus racemosa*) and smaller coast redwoods planted near the Surge and Woods Buildings. The redwoods range from 6 to 8 inches in diameter and are approximately 40 feet tall.

The majority of the forest understory is dominated by dense thickets of English ivy, German ivy (*Delairea oderata*), garden nasturtium (*Tropaeolum majus*) and Himalayan blackberry, all of which are considered invasive non-native species. English ivy is a dominant component throughout the entire forest understory, sprawling over the ground and climbing 50 feet aboveground on tree trucks. Native understory species are limited to occasional patches of honeysuckle vines (*Lonicera hispidula*), sword ferns (*Polystichum munitum*) and California blackberry (*Rubus ursinus*).

- **Himalayan Blackberry Brambles** (*Rubus armeniacus* Semi-Natural Stands). Although the majority of the forest understory is as described above, the abundance of Himalayan blackberry is worthy of mentioning due to its high invasive species ranking by the California Invasive Plant Inventory.[3] Himalayan Blackberry Brambles form impenetrable stands throughout the Reserve and often intermix with stands of California blackberry and poison oak, both of which are native.

- **Coastal Brambles** (*Rubus* sp. Shrubland Alliance). Himalayan Blackberry Brambles may be confused with California blackberry in stands of Coastal Brambles. This native vegetation likely dominated the headlands and exposed slopes of the Reserve prior to the late 1880s. Species typical of this vegetation type include bee plant (*Scrophularia californica*), twinberry (*Lonicera involucrata*), wild cucumber (*Marah fabaceous*), red elderberry, coyote brush, poison oak and sword fern. California blackberry and other associated species are common throughout the Reserve.

- **Coyote Brush Scrub** (*Baccharis pilularis* Shrubland Alliance). Due to habitat restoration efforts in the early 2000s, the Rotary Native Plant Garden most closely resembles Coyote Brush Scrub. Native shrubs present include California sagebrush (*Artemesia californica*), sticky monkeyflower (*Mimulus aurantiacus*), mugwort (*Artemesia douglasii*), lizard tail (*Eriophyllum staechadifolium*), cow parsnip (*Heracleum lanatum*), yellow bush lupine (*Lupinus arboreus*) and coyote brush. Small remnants of the non-native invasive French broom are also present despite efforts to remove it. A few coast live oaks have been planted around the clearing; other trees or large shrubs planted as part of the restoration effort include California buckeye (*Aesculus californica*), toyon (*Heteromeles arbutifolia*),

[3] LSA, p. 17.

California waxmyrtle (*Morella californica*) and red elderberry. Native herbaceous vegetation observed includes yarrow (*Achillea millefolium*), blue wild rye (*Elymus glaucus*), woodland strawberry (*Fragaria vesca*) and bee plant.

- **Non Vascular Flora**

**Bryophytes.** Bryophytes (commonly known as mosses and liverworts) can occur on all habitat on the Reserve. Although distributions are not well known for special-status bryophytes, the record search for plants revealed two occurrences of coastal triquetrella (*Triquetrella californica,* Rare Plant Rank 1B) in the immediate vicinity of the Reserve. Occurrence #4 is approximately 0.5 mile to the east at Tank Hill, and occurrence #3 consists of three observations at various open space sites between 1.1 and 1.7 miles east of the Reserve. Given the proximity of these records and the presence of suitable habitat on the Reserve (open gravels on roadsides, hillsides, and rocky slopes in coastal scrub), this species has the potential to occur in the project area. LSA collected bryophyte samples from various parts of the Reserve. None were identified as special-status species by LSA. However, special-status bryophytes could still occur in areas that were not sampled.

**Fungi.** Fungi (commonly known as mushrooms) are organisms typically treated as plants, though they belong to a different taxonomic kingdom. Currently there is no regulatory protection for fungi in California; therefore none are listed on the CNDDB. Although only a few fungi were identified in the Reserve, many more species of fungi are undoubtedly present in the Reserve.

**Lichens**. Lichens are organisms composed of a fungus and algae growing together. They occur in association with habitats and substrate types in the Reserve. Although the record search for plants did not reveal any occurrence of special-status lichens within a 10-mile radius of the site, a further radius search shows two special-status lichen species occurring in coastal Sonoma County: whiteworm lichen (*Thamnolia vermicularis*) and Methusela's beard lichen (*Usnea longissima*). The physiographic and climatic requirements of these two species do not occur on the Reserve: No special-status lichens were found during the brief surveys conducted by LSA, nor are they expected to occur here due to lack of suitable habitat.

- **Epiphytic Flora**

Plants that live on bark and trunks of trees or other plants are called epiphytes. The eucalyptus forest at the Reserve supports a wide variety of epiphytes including mosses, lichens and ferns. Leather fern (Polypodium scouleri) was observed growing on eucalyptus, blackwood acacia and Monterey cypress trunks and branches up to 30 feet above the forest floor. These observations indicate that epiphytes are non-specific when

selecting host species as long as environmental factors are suitable (i.e., fog drip, wind and textured bark). No other epiphytes were observed.

### 4.3.2.2 WILDLIFE

Many of the wildlife species expected to occur at the Reserve are generalists that have adapted to the urban environment and are able to co-exist with humans. Two site visits were conducted by LSA in July of 2010. A total of 26 bird species and one mammal species were observed during the site visit. Most of the species detected were birds, since they are more visible than amphibians, reptiles and mammals. Each of the taxonomic groups are described below.

- **Insects.** Native insect within the Reserve is expected to be low because of the dominance of non-native eucalyptus. As noted above, eucalyptus covers the majority of the site except the Rotary Native Plant Garden on the summit, which has been restored with native plant species. The insect fauna of the shady understory of the eucalyptus forest would include moths, flies, and beetles. Two species of eucalyptus borer may occur in the eucalyptus trees. Heavy infestation of these species may kill eucalyptus trees.

- **Amphibians and Reptiles.** Although no amphibians and reptiles were observed during LSA's site visits, the dense understory and the eucalyptus forest is likely to support common, urban-adapted species such as California slender salamander (*Batrachoseps attenuatus*), southern alligator lizard (*Elgaria multicarinatus*), Sierran treefrog (*Pseudacris sierra*), and common garter snake (*Thamnophis sirtalis*). Sunny, open areas with rock outcrops or other hard surfaces (e.g., at the summit) may support western fence lizards (*Sceloporus occidentalis*).

- **Birds.** The dense understory in the eucalyptus forest provides suitable nesting habitat for ground- and shrub-nesting species such as Pacific wren (*Troglodytes pacificus*), song sparrow (*Melospiza melodia*), and dark-eyed junco (*Junco hyemalis*). The Reserve is also one of the few sites in the City that support breeding Pacific-slope flycatchers (*Empidonax difficilis*), Swainson's thrushes (*Catharus ustulatus*) and Wilson's warblers (*Wilsonia pusillula*), all of which occur in moist drainages with scattered canopy openings that allow sunlight into the forest floor, such as the East Bowl Corridor (Demonstration Area #4). Olive-sided flycatcher (*Contopus cooperi*), a California Species of Special Concern and uncommon summer resident, was detected in the lower portion of the East Bowl Corridor during LSA's surveys and occurs on the Reserve every year, although its breeding success is constrained by predators, the common raven (*Corvus corax*). Cavity-nesting species such as downy woodpecker (*Picoides pubescens*), chestnut-backed chickadee (*Poecile rufescens*), brown creeper (*Certhia americana*), and pygmy nuthatch (*Sitta pygmaea*) likely nest in dead trees, snags, and trees with soft bark such as Monterey cypress. Scattered large trees throughout the Reserve provide suitable nest sites for urban-adapted raptors such as great horned owl (*Bubo virginianus*), red-shouldered hawk (*Buteo lineatus*) and Cooper's hawk (*Accipiter cooperi*).

The diverse native shrubs and the Rotary Native Plant Garden at the summit clearing provides optimal habitat for Anna's (*Calypte anna*) and Allen's (*Selasphorus sasin*) hummingbird, both of which were observed during LSA's site visits. The summit clearing was also the only place on the Reserve where Allen's hummingbird and orange-crowned warbler (*Oreothlypis celata*) were observed, likely due to its open habitat. Both species are known to breed on the Reserve.

During the winter, the resident bird community is augmented by species that breed further north or at higher elevations such as ruby-crowned kinglet (*Regulus calendula*), hermit thrush (*Catharus guttatus*), yellow-rumped warbler (*Dendroica coronata*), Townsend's warbler (*Dendroica townsendi*) and fox sparrow (*Passerella iliaca*). Mount Sutro is also one of several "islands" of vegetation in San Francisco that provide stopover habitat for migrant songbirds in the spring and fall. Some of the more regular migrants likely to occur include warbling vireo (*Vireo gilvus*), black-throated gray warbler (*Dendroica nigrescens*), yellow warbler (*Dendroica petechia*), western tanager (*Piranga ludoviciana*) and black-headed grosbeak (*Pheucticus melanocephalus*). In summary, the Reserve provides habitat for a variety of both resident and migratory bird species, including several that are locally uncommon or rare in San Francisco such as Pacific-slope flycatcher, Hutton's vireo, Pacific wren, Swainson's thrush, Wilson's warbler and orange-crowned warbler

- **Mammals.** Eastern fox squirrel (*Sciurus niger*) was the only mammal species observed during LSA's site visits, although other urban-adapted species such as Virginia opossum (*Didelphis virginiana*), deer mouse (*Peromyscus maniculatus*), house mouse (*Mus musculus*), northern raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*) and black-tailed deer (*Odocoileus hemionus*) are also expected to occur. Little is known about the status and distribution of bats in urban San Francisco, but species common to the Bay Area such as big brown bat (*Eptesicus fuscus*), Brazilian free-tailed bat (*Tadarida brasiliensis*), and Yuma myotis (*Myotis yumanensis*) likely forage on the Reserve. Migratory tree-roosting species such as hoary bat (*Lasiurus cinereus*) may occasionally roost in the trees during migration, due to the site's proximity to the Pacific coastline.

### 4.3.2.3 SPECIAL-STATUS SPECIES

#### Plants

Based on a review of the California Natural Diversity Database (CNDDB)[4] and the California Native Plant Society (CNPS), LSA identified 22 special-status plant species as potentially occurring in the general vicinity, listed in Table A. With the exception of the San Francisco gumplant (*Grindelia hirsutula* var. *maritima*) and coastal triquetrella (*Triquetrella californica*) which are briefly discussed below, none of the other species are expected to occur due to a lack of suitable habitat.

[4] Ibid. p. 21.

- **San Francisco Gumplant.** San Francisco gumplant is a plant with a California Rare Plant Rank of 1B. This species is considered rare in California where it occurs in coastal scrub and bluffs from San Luis Obispo County to Marin County. The closest extant record (CNDDB Occurrence #2) is attributed to a location on the west slope of Mount Sutro on San Francisco Public Utilities Commission property, adjacent to Laguna Honda. Although this population is on the Mount Sutro Stewards plant list, it is outside of the Reserve and isolated from it by urban development. Suitable habitat for this species occurs on the Reserve in coyote brush scrub and associated grassland habitat in the Rotary Native Plant Garden.

- **Coastal Triquetrella.** Coastal triquetrella is a moss with a California Rare Plant Rank of 1B and is considered rare in California with fewer than ten small coastal occurrences. Coastal triquetrella forms loose mats on exposed to shaded soil, rocks, sand, or gravel in dry or moist situations. The closest extant record (CNDDB Occurrence #4) is located less than 0.1 mile from the site on Tank Hill. Although this moss was not observed during the site visits, it may be present with other mosses on soil, gravels and rocks along trail sides, and within grassy areas with rocks.

## Animals

As shown in Table 4.3-1, the CNDDB contain records for 12 special-status animal species in the site vicinity. In addition, during the site visits, LSA detected a 13th species, the olive-sided flycatcher. With the exception of the monarch butterfly (*Danaus plexippus*), western red bat (*Lasiurus blossevillii*) and olive-sided flycatcher, which are briefly discussed below, none of the other species are expected to occur due to a lack of suitable habitat.

- **Monarch Butterfly.** Monarch butterflies have no special status under the California Fish and Game Code, but overwintering aggregations along the central California coast are considered sensitive by CDFW and impacts to known aggregation sites are typically considered significant under CEQA. Overwintering monarch aggregations typically form in groves of eucalyptus or Monterey pine along the coast by late October and usually break up in late February. Winter aggregations vary from 100 to many thousands of butterflies, which form clusters usually located between 20 and 60 feet (or higher) aboveground. Clusters within eucalyptus groves are often located within openings that allow sunlight to warm the aggregating butterflies.

  The CNDDB contains seven records for wintering monarch roosts in San Francisco, with the most recent occurring in the Presidio (east of Washington Boulevard and north of Compton Road) in 1998. Although no wintering monarch roosts have been observed in the Reserve to date, the dense eucalyptus forest provides suitable habitat for such roosts, particularly on the northern and eastern slopes that are sheltered from the prevailing westerly winds.

- **Western Red Bat.** Western red bat is a California Species of Special Concern. It is widespread in California and is typically solitary, roosting in tree foliage or shrubs. Day roosts are commonly in edge habitats adjacent to streams or open fields, in orchards, or sometimes in urban areas. In California, it is most commonly encountered in August and September when migrating. The CNDDB has one record of this species in San Francisco, where a single individual was seen roosting in Strybing Arboretum in Golden Gate Park on March 12, 2000. Migratory individuals may occasionally roost in trees within the Reserve, although detection of such individuals would be extremely difficult. The trees around the edge of the Rotary Native Plant Garden would likely provide the most suitable roosting habitat for this species, given its propensity for edge habitats.

- **Olive-sided Flycatcher.** Olive-sided flycatcher is a California Species of Special Concern. It is typically associated with late-successional forests with open canopies in mountainous portions of the state, but has expanded locally in lowlands of the San Francisco Bay region to occupy plantings of conifers and eucalyptus. Edges and openings within dense forests are its preferred habitat as such areas provide unobstructed airspace in which to forage for insects. Snags that protrude above the surrounding canopy are an important habitat component as they provide perches for singing and foraging. Open-cup nests are constructed on the upper surface of horizontal branches 5 to 70 feet up from the trunk, in clusters of live needles and twigs.

  Olive-sided flycatcher was confirmed as breeding during the San Francisco Breeding Bird Atlas effort in 1991 and 1992. LSA detected a single bird near the bottom of the East Bowl Corridor below Medical Center Way during the site visits conducted on July 12 and 27. On July 27, the bird was heard singing in the Monterey cypress trees immediately adjacent to the southern side of the Woods parking lot. This species is a regular summer resident on the Reserve but its breeding success is severely constrained by common raven predation. Given its preference for edge habitats, it is more likely to occur on the periphery of the Reserve and in larger openings within the forest than within dense portions of the forest with a closed canopy and limited sunlight.

**Table 4.3-1:**
**Special-status Species Potentially Occurring in the Vicinity of the Mount Sutro Open Space Reserve**

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| **PLANTS** | | | |
| *Amsinckia lunaris*<br>Bent-flowered fiddleneck | 1B | Annual grasslands. Blooms April to May. 3–500 meters. | Closest record (CNDDB occurrence #6) is located approximately 6.3 air miles to the south at San Bruno Mountain. The likelihood of this species occurring on the Reserve is low due to the density of and competition from exotic vegetation. |
| *Arctostaphylos franciscana* | 1B | Serpentine outcrops in chaparral. 60-300 meters. | Considered extinct until one plant was discovered during a road construction project in the Presidio of San Francisco. Highly unlikely to occur on the Reserve due to lack of suitable serpentine habitat. |
| *Arctostaphylos hookeri* ssp. *ravenii*<br>Presidio manzanita | FE, SE, 1B | Chaparral, coastal prairie, coastal scrub/serpentinite outcrop. Blooms February to March. 45–215 meters. | Closest extant record (CNDDB occurrence #4) is attributed to a reintroduction of the plant at Baker's Beach near the WWII Memorial, approximately 2.6 miles from the Reserve. Not expected to occur due to lack of suitable habitat. |
| *Arctostaphylos imbricata*<br>San Bruno manzanita | SE, 1B | Chaparral or coastal scrub on San Bruno Mountain; mostly known from a few sandstone outcrops<br>Blooms February to May. 275–370 meters. | Not expected to occur due to lack of suitable habitat; species distribution limited to San Bruno Mountain. |
| *Arctostaphylos montaraensi*<br>Montara manzanita | 1B | Coastal chaparral, coastal scrub. Blooms January to March. 150–500 meters. | Closest record (CNDDB occurrence #8) is located approximately 4.9 air miles to the south near the summit of San Bruno Mountain. The likelihood of this species occurring on site is low due to the density of competing non-native vegetation. |
| *Arctostaphylos pacifica*<br>Pacific manzanita | SE, 1B | Coastal scrub associated with sandstone and other species of *Arctostaphylos*. Known only from San Bruno Mountain. Blooms February to April. | Closest record (CNDDB occurrence #1) is located approximately 5.3 air miles to the south near the summit of San Bruno Mountain. Not expected to occur; species distribution limited to San Bruno Mountain. |
| *Cirsium andwersii*<br>Franciscan thistle | 1B | Coastal bluff scrub, coastal prairie, broadleafed upland forest; sometimes occurs in serpentine seeps. Blooms March to July. 0-150 meters. | Closest presumed extant record (CNDDB occurrence #7) is approximately 1.9 miles to the north near Mountain Lake in the Presidio. Not expected to occur due to disturbance and lack of suitable habitat. |
| *Cirsium occidentale var. compactum*<br>Compact cobwebby thistle | 1B | Chaparral, coastal dunes, coastal prairie, coastal scrub. Blooms April to June. 5–150 meters. | Closest possibly extirpated record (CNDDB occurrence #15) approximately 2.7 miles to the south near Lake Merced. Not expected to occur due to prior disturbance and lack of suitable habitat |
| *Clarkia franciscana*<br>Presidio clarkia | FE, SE, 1B | Coastal scrub, valley and foothill grassland, sometimes on serpentine. Blooms May to July. 25–335 meters. | Closest presumed extant record (CNDDB occurrence #2) is attributed to a reintroduction of the plant to serpentine grasslands at the Presidio approximately 1.9 miles to the north. Not expected to occur due to lack of suitable habitat. |
| *Collinsia corymbosa*<br>Round-headed Chinese-houses | 1B | Coastal dunes. Blooms April to June. 0–20 meters. | Closest presumed extant record (CNDDB occurrence #1) is attributed to a collection made in 1902 at the Presidio approximately 1.1 miles to the north. Not expected to occur due to lack of suitable habitat. |

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| *Collinsia multicolor*<br>San Francisco collinsia | 1B | Closed-cone coniferous forest, coastal scrub and grassland on decomposed shale (mudstone) mixed with humus. Sometimes on serpentinite. Blooms March to May. 30–250 meters. | Closest presumed extant record (CNDDB occurrence #16) is attributed to a collection made in 1929 at Glen Canyon Park approximately 0.6 miles to the southeast. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Fritillaria liliacea*<br>Fragrant fritillary | 1B | Grasslands in coastal scrub and coastal prairie, often on serpentine and usually in clay soils but various soil types are reported. Blooms February to April. 3–410 meters. | Closest presumed extant record (CNDDB occurrence #61) is attributed to an observation mentioned in an undated article by Mike Wood. The location is from the Twin Peaks area approximately 0.3 miles to the south. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Grindelia hirsutula* var. *maritima*<br>San Francisco gumplant | 1B | Coastal scrub, grassland; sandy or serpentine slopes, sea bluffs, valley and foothill grassland. Blooms June to September. 15–400 meters. | Closest extant record (CNDDB occurrence #2) is attributed to a location on the west slope of Mount Sutro outside of the Reserve. Although this plant is on the Mount Sutro Stewards plant list, the known population is isolated from the Reserve habitat and it was not observed on the Reserve during LSA surveys. |
| *Helianthella castanea*<br>Diablo helianthella | 1B | Thin, rocky soils on grassy hillsides and in cismontane woodland, usually at the scrub/chaparral/oak woodland interface. Blooms April to May. 150–1,220 meters. | Closest presumed extant record (CNDDB occurrence #11) is attributed to a collection made in 1899 at Bay View Hill approximately 3.6 miles to the southeast. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Hesperolinon congestum*<br>Marin western flax | FT, ST, 1B | Chaparral, valley and foothill grassland/serpentinite. Blooms April to July. 5–370 meters. | Closest extant record (CNDDB occurrence #16) is attributed to an attempted reintroduction at Baker Beach, approximately 2.6 miles to the north. Not expected to occur due to lack of suitable habitat. |
| *Pentachaeta bellidiflora*<br>White-rayed pentachaeta | FE, ST, 1B | Cismontane woodland valley and foothill grassland, often on open, dry rocky slopes. Blooms March to May. 35–620 meters. | The closest record (CNDDB #6) is from the east edge of San Bruno Mountain, approximately 6.5 air miles to the south-southeast. Not expected to occur due to lack of suitable habitat. |
| *Plagiobothrys chorisianus var. chorisianus*<br>Choris' popcorn-flower | 1B | Chaparral, coastal prairie, coastal scrub, mesic sites. Blooms March to June. 15–160 meters. | Closest presumed extant record (CNDDB occurrence #12) is approximately 0.2 miles to the north in Golden Gate Park as documented in the *Flora of San Francisco*. Not expected to occur due to prior disturbance and lack of suitable habitat |
| *Plagiobothrys diffusus*<br>San Francisco popcorn flower | SE, 1B | Coastal prairie, valley and foothill grassland. Blooms March to June. 60–360 meters. | Closest presumed extant record (CNDDB occurrence #2) is approximately 1.7 miles to the north on clay flats near Mountain Lake in the Presidio. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Polemonium carneum*<br>Oregon polemonium | 2 | Coastal prairie, coastal scrub, lower montane coniferous forest. Blooms April to September. 0–1,830 meters. | Closest presumed extant record (CNDDB occurrence #5) is attributed to a 1939 collection from Point Bonita in Marin County, approximately 4.4 miles to the north. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Silene verecunda* ssp. *verecunda*<br>San Francisco campion | 1B | Coastal bluff scrub, grassland, chaparral, coastal prairie, sandy areas in valley and foothill grassland. Blooms March to June. 30–645 meters. | Closest presumed extant record (CNDDB occurrence #8) is approximately 1 mile south of the Reserve at Mt. Davidson. This population is on rock slopes of Franciscan greywacke, threatened by blue gum eucalyptus and German ivy. Not expected to occur due to prior disturbance and lack of suitable habitat. |

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| *Stebbinsoseris decipiens* Santa Cruz microseris | 1B | Broadleafed upland forest, closed-cone coniferous forest, chaparral, coastal prairie, coastal scrub, often in open areas and sometimes serpentinite in valley and foothill grassland. Blooms April to May. 10-500 meters. | Closest record (CNDDB occurrence #18) is approximately 7.3 air miles to the north on Angel Island. Not expected to occur due to lack of suitable habitat. |
| *Triphysaria floribunda* San Francisco owl's-clover | 1B | Coastal prairie, coastal scrub, usually on serpentine in valley and foothill grassland. Blooms April to June. 10–160 meters. | Closest extant record (CNDDB occurrence #19) is attributed to a declining population at the Presidio, approximately 2.6 miles to the north. Not expected to occur due to lack of suitable habitat. |
| *Triquetrella californica* Coastal triquetrella | 1B | Coastal bluff scrub, on soil in coastal scrub. 10–100 meters. | Closest extant record (CNDDB occurrence #4) is located less than 0.1 mile from the Reserve on Tank Hill. Like other mosses, coastal triquetrella grows over rocks, on soil, and within grassy areas with rocks. Although this moss was not observed during the fieldwork, it could have easily been overlooked and may be present on the project site. |
| **ANIMALS** | | | |
| San Bruno elfin butterfly *Callophrys mossii bayensis* | FE | Coastal mountains with grassy ground cover, mainly in the vicinity of San Bruno Mountain; colonies located on steep, north-facing slopes in fog belt; host plant is *Sedum spathulifolium*. | Not expected to occur due to lack of suitable larval food plant and habitat; species distribution limited to San Bruno Mountain |
| Mission blue butterfly *Plebejus icarioides missionensis* | FE | Grasslands of the San Francisco peninsula; three larval host plants: *Lupinus albifrons*, *L. variicolor*, and *L. formosus*. | Not expected to occur due to lack of suitable larval food plant and habitat. |
| Callippe silverspot butterfly *Speyeria callippe callippe* | FE | Coastal scrub of the San Francisco peninsula; host plant is *Viola pedunculata*, most adults found on east-facing slopes. | Not expected to occur due to lack of suitable larval food plant and habitat. |
| Monarch butterfly (wintering roosts) *Danaus plexippus* | CEQA | Protected areas in groves of trees with dense canopy cover and nearby water and nectar sources. | May occur. Dense eucalyptus in sheltered portions of Reserve provide suitable habitat. |
| California red-legged frog *Rana draytonii* | FT, CSC | Ponds, streams, drainages and associated uplands; requires areas of deep, still, and/or slow-moving water for breeding. | Not expected to occur due to lack of suitable aquatic habitat. |
| Western pond turtle *Actinemys marmorata* | CSC | Ponds, streams, drainages and associated uplands. | Not expected to occur due to lack of suitable aquatic habitat. |
| San Francisco garter snake *Thamnophis sirtalis tetrataenia* | FE, SE | Freshwater marshes, ponds, and slow-moving streams in San Mateo County and extreme northern Santa Cruz County; prefers dense cover and water depths of at least 1 foot. | Not expected to occur due to lack of suitable aquatic habitat. Project area is outside of known range. |
| California black rail *Laterallus jamaicensis* coturniculus | ST | Salt marshes bordering larger bays, also found in brackish and freshwater marshes. | Not expected to occur due to lack of suitable marsh habitat. |
| Olive-sided flycatcher *Contopus cooperi* | CSC | Edges, openings, and natural and human-created clearings in otherwise dense forests. Cup nests constructed on the upper surface of conifer, willow, alder, oak, and/or eucalyptus branches. | Known to occur. Singing individual detected near lower East Bowl Corridor during LSA site visits; occurs every year but successful breeding appears to be constrained by common raven predation (J. Clark, pers. comm.) |
| Bank swallow *Riparia riparia* | SE | Vertical banks or cliffs with fine-textured or sandy soils near streams, rivers, lakes, or ocean; colonial nester. | Migrating individuals may rarely fly over but otherwise not expected to occur due to lack of suitable habitat. |
| Salt marsh common yellowthroat *Geothylpis trichas sinuosa* | CSC | Salt, brackish, and freshwater marshes; and riparian woodlands; nests on or near ground in low vegetation | Not expected to occur due to lack of suitable marsh habitat. |

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| Western red bat *Lasiurus blossevillii* | CSC | Roosts primarily in foliage of trees and shrubs. Day roosts commonly in edge habitats adjacent to streams or open fields. | Migratory individuals may occasionally roost in trees in Reserve for brief periods. |
| American badger *Taxidea taxus* | CSC | Open, dry habitats (e.g., grasslands) with friable soils. | Not expected to occur due to lack of suitable open habitat. |

Status
FE = federally listed as endangered
FT = federally listed as threatened
SE = State-listed as endangered
ST = State-listed as threatened
CSC = California Species of Special Concern
CFP = California Fully Protected Species
1B = California Rare Plant Rank 1B: species considered rare or endangered in California and elsewhere
2 = California Rare Plant Rank 2 – rare, threatened or endangered in California, but more common elsewhere.
CEQA = considered rare under Section 15380 of CEQA

## 4.3.3 REGULATORY CONSIDERATIONS

Biological resources in the project area may fall under the jurisdiction of State and/or federal regulatory agencies and may be subject to various statutes, regulations, and/or codes as described below.

### 4.3.3.1 FEDERAL

#### Federal Endangered Species Act

The United States (U.S.) Fish and Wildlife Service (USFWS) has jurisdiction over federally listed threatened and endangered plant and animal species. The federal Endangered Species Act (ESA) protects listed species from harm or "take," broadly defined as to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." Any such activity can be defined as a "take" even if it is unintentional or accidental. An endangered species is one that is considered in danger of becoming extinct throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered in the foreseeable future.

In addition to endangered and threatened species, which are legally protected under the ESA, the USFWS maintains lists of proposed and candidate species. Proposed species are those for which a proposed rule to list them as endangered or threatened has been published in the Federal Register. A candidate species is one for which the USFWS currently has enough information to support a proposal to list it as a threatened or endangered species. Proposed species could be listed at any time, and many federal agencies protect them as if they already are listed. Candidate species are not afforded legal protection under the ESA.

## Clean Water Act

The U.S. Army Corps of Engineers (Corps) is responsible under Section 404 of the Clean Water Act to regulate the discharge of fill material into waters of the U.S. Waters of the U.S. and their lateral limits are defined in 33 Code of Federal Regulations (CFR) Part 328.3(a) and include streams that are tributaries to navigable waters and their adjacent wetlands. The lateral limits of jurisdiction for a non-tidal stream are measured at the line of the Ordinary High Water Mark (OHWM) (33 CFR Part 328.3[e]) or the limit of adjacent wetlands (33 CFR Part 328.3[b]). Any permanent extension of the limits of an existing water of the U.S., whether natural or man-made, results in a similar extension of Corps jurisdiction (33 CFR Part 328.5).

Waters of the U.S. fall into two broad categories: wetlands and other waters. Other waters include unvegetated waterbodies and watercourses such as rivers, streams, lakes, springs, ponds, coastal waters, and estuaries. Seasonally inundated or intermittent waterbodies or watercourses that do not exhibit wetland characteristics are often classified as other waters of the U.S. Wetlands include marshes, wet meadows, seeps, floodplains, basins, and other areas experiencing extended seasonal or permanent soil saturation that support wetland vegetation. Seasonally or intermittently inundated features, such as seasonal ponds, ephemeral streams, and tidal marshes, are categorized as wetlands if they have hydric soils and support wetland plant communities.

Wetlands and other waters that cannot trace a continuous hydrologic connection to a navigable water of the U.S. are not tributary to waters of the U.S. These are termed "isolated" wetlands and waters. Isolated wetlands and waters are jurisdictional when their destruction or degradation can affect interstate or foreign commerce (33 CFR Part 328.3[a]). The Corps may or may not take jurisdiction over isolated wetlands, depending on the specific circumstances.

In general, a Section 404 permit must be obtained from the Corps before filling or grading jurisdictional wetlands or other waters of the U.S. Certain projects may qualify for authorization under a Nationwide Permit (NWP). The purpose of the NWP program is to streamline the evaluation and approval process throughout the nation for certain types of activities that have only minimal impacts to the aquatic environment. Many NWPs are only authorized after the applicant has submitted a pre-construction notification (PCN) to the appropriate Corps office. The Corps is required to consult with the USFWS and/or the National Marine Fisheries Service (NMFS) under Section 7 of the ESA if the permitted activity may result in the take of federally listed species.

## Migratory Bird Treaty Act

The federal Migratory Bird Treaty Act (MBTA) prohibits the taking, hunting, killing, selling, purchasing, etc. of migratory birds, parts of migratory birds, or their eggs and nests. As used in the MBTA, the term "take" is defined as "to pursue, hunt, shoot, capture, collect, kill, or attempt to pursue, hunt, shoot, capture, collect, or kill, unless the context otherwise requires." Most bird species native to North America are covered by this act (16 USC 703-712).

## 4.3.3.2 CALIFORNIA

### California Endangered Species Act

The California Department of Fish and Wildlife (CDFW) has jurisdiction over threatened or endangered species that are formally listed by the State under the California ESA. The California ESA is similar to the federal ESA both in process and substance; it is intended to provide additional protection to threatened and endangered species in California. Species may be listed as threatened or endangered under both acts (in which case the provisions of both state and federal laws apply) or under only one act. A candidate species is one that the Fish and Game Commission has formally noticed as being under review by CDFW for addition to the State list. Candidate species are protected by the provisions of the California ESA.

### Porter-Cologne Water Quality Control Act

Under this Act (California Water Code Sections 13000–14920), the RWQCB is authorized to regulate the discharge of waste that could affect the quality of the State's waters. Therefore, even if a project does not require a federal permit, it may still require review and approval by the RWQCB (e.g., for impacts to isolated wetlands and other waters). When reviewing applications, the RWQCB focuses on ensuring that projects do not adversely affect the "beneficial uses" associated with waters of the State. In most cases, the RWQCB seeks to protect these beneficial uses by requiring the integration of water quality control measures into projects that will require discharge into waters of the State. For most construction projects, the RWQCB requires the use of construction and post-construction best management practices (BMPs).

### California Fish and Game Code

The CDFW is also responsible for enforcing the California Fish and Game Code, which contains several provisions potentially relevant to construction projects. For example, Section 1602 of the Fish and Game Code (CCR; Title 14, Div. 1) governs the issuance of Lake and Streambed Alteration Agreements by the CDFW. Lake and Streambed Alteration Agreements are required whenever project activities substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake designated as such by the CDFW. Section 1602 of the Fish and Game Code applies to all perennial, intermittent, and ephemeral rivers, streams, and lakes in the state.

The Fish and Game Code also lists animal species designated as Fully Protected, which may not be taken or possessed at any time. The Fully Protected designation does not allow "incidental take" and is thus more restrictive than the CESA. Fully Protected species are listed in Sections 3511 (birds), 4700 (mammals), 5050 (reptiles and amphibians), and 5515 (fish) of the Fish and Game Code, while protected amphibians and reptiles are listed in Chapter 5, Sections 41 and 42 (CCR; Title 14, Div. 1).

Section 3503 of the Fish and Game Code (CCR; Title 14, Div. 1) prohibits the take, possession, or needless destruction of the nest or eggs of most bird species. Subsection 3503.5 (CCR; Title 14, Div. 1) specifically prohibits the take, possession, or destruction of any birds in the orders Falconiformes (hawks and eagles) or Strigiformes (owls) and their nests. These provisions, along with the federal MBTA, serve to protect nesting native birds. Certain non-native species, including European starling and house sparrow, are not protected under the MBTA or California Fish and Game Code**.**

## California Species of Special Concern

The CDFW maintains an administrative list of Species of Special Concern (SSC), defined as a "species, subspecies, or distinct population of an animal native to California that currently satisfies one or more of the following (not necessarily mutually exclusive) criteria: is extirpated from the State, or, in the case of birds, in its primary seasonal or breeding role; is listed as federally, but not State, threatened or endangered; meets the State definition of threatened or endangered but has not formally been listed; is experiencing, or formerly experienced, serious (noncyclical) population declines or range retractions (not reversed) that, if continued or resumed, could qualify it for State threatened or endangered status; and has naturally small populations exhibiting high susceptibility to risk from any factor(s), that if realized, could lead to declines that would qualify it for State threatened or endangered status."

The CDFW's Nongame Wildlife Program is responsible for producing and updating SSC publications for mammals, birds; and reptiles and amphibians. The Fisheries Branch is responsible for updates to the Fish SSC document and list. Section 15380 of the CEQA Guidelines indicates that SSC should be included in an analysis of project impacts if they can be shown to meet the criteria of sensitivity outlined therein. In contrast to species listed under the federal or California ESAs, however, SSC have no formal legal protective status.

## California Rare Plant Ranks

Special-status plants in California are assigned to one of five "California Rare Plant Ranks" by a group of over 300 botanists in government, academia, non-governmental organizations, and the private sector. This effort is jointly managed by the CDFW and the non-profit California Native Plant Society (CNPS). The five California Rare Plant Ranks currently recognized by the CNDDB include the following:

- Rare Plant Rank 1A – presumed extinct in California
- Rare Plant Rank 1B – rare, threatened, or endangered in California and elsewhere
- Rare Plant Rank 2 – rare, threatened, or endangered in California but more common elsewhere
- Rare Plant Rank 3 – a review list of plants about which more information is needed
- Rare Plant Rank 4 – a watch list of plants of limited distribution

Substantial impacts to plants ranked 1A, 1B and 2 are typically considered significant based on Section 15380 of the CEQA Guidelines depending on the policy of the lead agency. Plants ranked 3 and 4 may be evaluated by the lead agency on a case-by-case basis to determine significance thresholds under CEQA.

## 4.3.3.3 LOCAL PLANS AND POLICIES

### San Francisco Urban Forestry Ordinance

The San Francisco Urban Forestry Ordinance (i.e., Article 16 of the San Francisco Public Works Code) was enacted to ensure the protection of trees on private land within and adjacent to public areas. The City and County of San Francisco currently considers "Protected Trees" as street trees, significant trees, and landmark trees. These tree types are defined as follows:

- Landmark trees have the highest level of protection in the City, and meet criteria for age, size, shape, species, location, historical association, visual quality, or other contribution to the City's character and have been found worthy of landmark status after public hearings at both the Urban Forestry Council and the Board of Supervisors. Temporary landmark status is also afforded to nominated trees undergoing the public hearing process.
- Significant trees are those that are within 10 feet of the property edge of the sidewalk that are above 20 feet in height, or with a canopy greater than 15 feet in diameter, or with a trunk diameter greater than 12 inches at breast height.
- Street trees are trees within the public right-of-way. Street trees may be maintained by either the property owner or the City.

Removal of any of these trees on private land is not prohibited but requires a permit from the Department of Public Works, subject to review against certain criteria and public notification. If any construction activity is to occur within the dripline of any protected tree, a tree protection plan prepared by an International Society of Arboriculture (ISA)-certified arborist must be submitted to the Planning Department for review and approval prior to the issuance of a building permit. All permit applications that could potentially impact a protected tree must include a Planning Department "Tree Disclosure Statement" form, which constitutes the applicant's legal declaration of all trees on the property. As part of the Tree Disclosure Statement, applicants must identify and show accurately the size of the trunk diameter and canopy dripline in relation to the proposed project on site plans. The Reserve is not privately owned. It is designated permanent open space by The Regents of the University of California, and is open to the public. Additionally, UCSF is constitutionally exempt from local jurisdiction regulations whenever using property under its control in support of its educational mission. Therefore, UCSF would not be subject to this Ordinance.

## 4.3.4 SENSITIVE HABITATS

No wetlands potentially subject to the U.S. Army Corps of Engineers (Corps) and/or Regional Water Quality Control Board (RWQCB) jurisdiction were identified during LSA's site visits. The

steep topography over most of the site prevents the establishment of ponded depressions, seasonal wetlands or other features that retain water long enough to support hydric soils and hydrophytic vegetation. The East Bowl Corridor contains a channel, Woodland Creek, that may be subject to Corps jurisdiction as other waters of the U.S. Although the channel did not contain any water during LSA's site visits, it likely conveys storm flows to the City's storm water system during the rainy season and could be considered an intermittent stream. Since most, if not all, of the City's storm drains lead to San Francisco Bay, the Corps could exert jurisdiction over discharges of fill material below the ordinary high water mark of the intermittent stream since it is tributary to navigable waters of the U.S. The intermittent stream may also be subject to CDFW jurisdiction requiring a Lake of Streambed Alteration Agreement (LSSA) for ground disturbing activities under Section 1602 of the California Fish and Game Code.

## 4.3.5 SIGNIFICANCE STANDARDS AND METHODOLOGY

### Significance Criteria

According to Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment if it would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFW or U.S. Fish and Wildlife Service;
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFW or US Fish and Wildlife Service;
- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means;
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites;
- Conflict with any applicable policies protecting biological resources, included tree preservation policy or ordinance;
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan; or
- Exceed the applicable LRDP EIR standard of significance by damaging or removing heritage or landmark trees or native oak trees of a diameter specified in a local ordinance.

## 4.3.6 IMPACTS AND MITIGATION MEASURES

As discussed in the NOP/Initial Study for the UCSF Mount Sutro Management Project, there are no federally protected wetlands on the project site, and no adopted habitat conservation plans, natural community conservation plans, or other applicable habitat conservation plan that would be applicable to the project, nor does the site contain any heritage or landmark trees specified in a local ordinance, therefore, the project would have no impact to those significance criteria and will not be analyzed in the EIR.

**Impact BIO-1: The project could have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFW or U.S. Fish and Wildlife Service. (Significant; Less than Significant with Mitigation)**

The proposed tree removals could impact roosting bats, if present within the Reserve. Individual western red bats potentially roosting on the Reserve during its August-September migratory period are unlikely to be substantially affected by tree removals since the majority of existing large trees on the Reserve would be retained. Individual bats potentially roosting in the foliage of trees to be removed would be temporarily disturbed by removal activities, but would be able to fly away and seek alternative roost sites nearby. It is highly unlikely that the proposed tree removals would result in western red bat mortality. As such, potential project impacts on western red bats are considered less than significant. However, impacts to maternity colonies of common bat species could be considered significant and are discussed below under Impact 4.

The proposed project is not expected to impact nesting olive-sided flycatchers (California Species of Special Concern) if tree removals are conducted outside the nesting season of February 15-August 15. In addition, implementation of **Mitigation Measure BIO-1a**, below, will ensure that potential impacts to olive-sided flycatchers would be unlikely and impacts would be less than significant.

**Impact BIO-1a: Monarch Butterflies.** The proposed project could remove trees that support overwintering aggregation of monarch butterflies. The dense eucalyptus grove provides suitable roosting conditions for wintering monarch butterflies. Removal of any trees supporting such roosts during the wintering season (October-February) would be considered a significant impact. Implementation of the following mitigation measure would reduce this impact to less-than-significant level.

**Mitigation Measure BIO-1a**: Prior to any tree removal, if that was to occur in the winter season (October-February), a qualified biologist familiar with monarch butterfly aggregating behavior and habitat shall conduct a survey of all tree removal area for the presence of overwintering monarch butterfly aggregations. The survey shall be conducted in December or January since aggregation is well-established by then. If any trees are identified as supporting monarch butterfly aggregations, such trees shall be clearly marked in the field and on project plans so that

a 200-foot buffer could be established around the tree(s) during tree removal operations until the aggregation has dispersed.

**Significance after Mitigation:** Less than Significant

**Impact BIO-1b: Coastal Triquetrella.** Coastal triquetrella is a moss with a California Rare Plant Rank of 1B and is known from fewer than 10 small coastal occurrences, including one within .01 mile from the project area. It would be considered a significant impact if access or staging areas substantially disturb suitable habitat on open gravel sites. Implementation of the following mitigation measure would reduce this impact to a less-than-significant level.

**Mitigation Measure BIO-1b:** Prior to project implementation, a qualified biologist familiar with identification of coastal triquetrella shall conduct a survey of all the access and staging areas located in suitable open gravel habitat for the presence of coastal triquetrella. The survey could be conducted at any time of the year because coastal triquetrella is identifiable from vegetative characteristics, year round. If coastal triquetrella is identified as occurring in areas that would be subject to ground disturbance, the occurrence(s) shall be clearly marked in the field and on the project plans so that the areas would be avoided during access and staging operations.

**Significance after Mitigation:** Less than Significant

**Impact BIO-2: The project could have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations by the CDFW or US Fish and Wildlife Service. (Less than Significant)**

As noted above, no riparian habitat or other sensitive natural communities are present on the project site. However, the intermittent stream on the eastern side of the Reserve (i.e., East Bowl Corridor) may be subject to CDFW jurisdiction under Section 1602 of the California Fish and Game Code. Prior to project implementation, UCSF will contact CDFW to determine whether a Lake or Streambed Alteration Agreement (LSAA) would be necessary for the proposed activities in the East Bowl Corridor. The project does not call for discharge of any fill material into waters of the U.S., and activities within CDFW jurisdiction below the top of bank would be limited to removal of non-native vegetation and planting of native vegetation. Although an LSAA may be required for such activities, the proposed project is not expected to have a substantial adverse effect on the stream since proposed activities in the East Bowl Corridor are intended to re-establish a native riparian plant community dominated by coast redwood, California bay and willows and would result in long-term benefits associated with increased wildlife habitat and native plant diversity. Any short-term impacts associated with construction-related disturbance would be avoided by implementing the BMPs, which are incorporated as part of the project description. Therefore, impacts to any riparian habitat or other sensitive natural community would be less than significant.

**Mitigation:** None required

**Impact BIO-3: The project could have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means. (Less than Significant)**

As noted above, the intermittent channel in the East Bowl Corridor could be considered a jurisdictional wetland if it supports wetland vegetation. The area of the channel below the ordinary high water mark would likely be considered to fall under the Corp's jurisdiction as other waters of the U.S. However, the proposed project does not propose the discharge of any fill material into waters of the U.S., and activities within CDFW jurisdiction below the top of bank would be limited to removal of non-native vegetation and planting of native vegetation. In addition, the BMP's which are incorporated as part of the proposed project, would avoid sedimentation and other forms of pollution, and other adverse effects to the channel. Therefore, Section 404 permits would not be required and impacts to federally protected wetlands would be less than significant.

**Mitigation:** None required

**Impact BIO-4: The project could interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites. (Significant; Less than Significant with Mitigation)**

The Reserve does not constitute a wildlife corridor because it does not facilitate wildlife movement through the urban landscape of San Francisco. While it provides habitat for many urban-adapted wildlife species, it is isolated from other patches or areas of similar habitat in San Francisco due to the dense development in the intervening urban spaces. Species that use and move through the Reserve, such as northern raccoons, are opportunistic generalists that are equally adept at moving through both high-density residential neighborhoods and undeveloped open spaces. The relatively limited amount of vegetation removal that would occur within the Reserve will not interfere substantially the movement of existing wildlife through the Reserve. Therefore, potential impacts on these wildlife species from tree thinning and vegetation removal would be less than significant.

Large trees with deep cavities within the Reserve could potentially support maternity colonies of common bat species such as big brown bat or Brazilian free-tailed bat. None of the trees proposed to be removed would be large enough to support cavities suitable for bat roosting, therefore bat maternity colonies would not be impacted. Due to the large areas of suitable roosting habitat that will be protected on the project site, individual tree roosting bats are not likely to be impacted by the proposed tree removal. Individual bats roosting in trees during tree removal will likely fly away and seek alternative roost sites when disturbed. Therefore, potential impacts on bats from tree thinning and vegetation removal would be less than significant.

**Impacts BIO-4a Active Bird Nests and BIO-4b Raptor Nesting**: The proposed tree thinning and vegetation removal is proposed to be conducted outside the nesting season for most bird species (February 15-August 15). However, early nesting species such as great horned owl and Anna's hummingbird could potentially be impacted by such activities. Should the proposed tree thinning and other vegetation removal occur during the primary nesting season, these activities could directly impact nesting birds by removing trees or shrubs that support active nests. Construction-related disturbance (e.g., noise, vehicle traffic, personnel working adjacent to suitable nesting habitat) could also indirectly impact nesting birds by causing adults to abandon nests in nearby trees or other vegetation, resulting in nest failure and reduced reproductive potential. As discuss above, in Section 4.1.3, Regulatory Considerations, nests of native birds are protected under the Federal Migratory Bird Treaty Act and California Fish and Game Code. Implementation of **Mitigation Measure BIO-4a and BIO-4b** would reduce any potential impact to nesting birds to a less-than-significant level.

**Mitigation Measure BIO-4a:** While it is anticipated that the proposed tree thinning and vegetation removal activities would be scheduled outside of the nesting season, this may not always be feasible. Prior to any tree thinning and vegetation removal activities that would occur between December 15 (for early-nesting species) and August 15, a qualified biologist shall conduct a preconstruction nest survey of all suitable nesting habitat on and within 50 feet of the limits of work. The contractor shall clearly delineate the trees and other vegetation proposed for removal to ensure that the biologist surveys the work area as thoroughly as possible. If the survey indicates the presence of nesting birds, the biologist shall determine the appropriate sized buffer around the nest in which no work would be allowed until the young have successfully fledged or the nest has failed. The size of the buffer shall be determined by the biologist and shall be based on the nesting species and its sensitivity to disturbance. In general, the buffer for raptors is up to 250 feet and the buffers for other bird species are 50 feet. Depending on the bird species, site conditions and the level of disturbance anticipated near the nest, the buffers may be increased or decreased. Implementation of **Mitigation Measures 4a and 4b** would reduce impacts to potential nesting birds and raptors to a less-than-significant level.

**Significance after Mitigation:** Less than Significant

**Mitigation Measure BIO-4b Raptor Nesting:** In addition, prior to any tree thinning and removal activities, a qualified biologist familiar with raptor nesting habitat shall examine the treatment area for mature trees that should be retained to provide raptor nesting habitat. Dead snags that provide habitat for woodpeckers and other cavity-nesting species should also be retained to the degree possible. Trees and/or snags recommended for retention should be clearly marked both in the field and on the project plans so they are not removed during tree thinning and understory removal activities. Implementation of **Mitigation Measures 4a and 4b** would reduce impacts to potential nesting birds and raptors to a less-than-significant level.

**Significance after Mitigation:** Less than Significant

**Impact BIO-5: The project could conflict with any applicable policies protecting biological resources, including any tree preservation policy or ordinance. (Less than Significant)**

A tree inventory of the existing trees within the treatment areas has not been conducted. As defined in Section 4.1.3, Regulatory Considerations, protected trees in San Francisco include Landmark trees, significant trees, and street trees. Several trees within the project area would qualify for protected status under the San Francisco Urban Forestry Ordinance if they were on privately owned land. Protected trees include the following:

- Landmark Trees – UCSF has none at its Parnassus Heights Campus, including the Reserve.
- Significant Trees – trees within 10 feet of property line that are taller than 20 feet or with a canopy greater than 15 feet or with a trunk greater than 12 inches at breast height. Individual trees meeting these criteria that pose a hazard to life or property may be removed for the proposed project.
- Street Trees – no street trees would be removed as part of this project.

As noted previously, the Reserve is designated by The Regents as permanent open space and is open to the public, not only for UCSF but the greater community. The Reserve is not privately owned and UCSF would not be subject to this Ordinance. The proposed project would implement vegetation management activities to restore and enhance the Reserve, in consultation with qualified arborists and urban forestry professionals. By implementing **Mitigation MeasuresBIO-4a and 4b**, any potential impact to nesting birds due to the proposed tree thinning and removal would be reduced to a less-than-significant level. In addition, UCSF has conducted substantial public outreach regarding the proposed project, and would continue to do so, which would provide a suitable substitute for the public notice requirements of the Urban Forestry Ordinance (DPW Code Article 16). Accordingly, the proposed project would not conflict with any local policies or ordinances protecting biological resources and impacts would be less than significant.

**Mitigation:** None required

**Impact BIO-6: The project could conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan. (Less than Significant)**

The Reserve and the demonstration areas are not within any lands subject to local, regional or State habitat conservation plan. Therefore, the proposed project would not have an impact on this topic area.

**Mitigation:** None required

**Impact BIO-7: The project could exceed the applicable LRDP EIR standard of significance by damaging or removing heritage or landmark trees or native oak trees of a diameter specified in a local ordinance. (Less than Significant)**

The Reserve and the demonstration areas do not contain any heritage or landmark trees specified in a local ordinance. Therefore, the proposed project would not have an impact on this topic area.

**Mitigation:** None required

**Impact BIO-8: The proposed project, in combination with other planned and foreseeable future projects, would result in a cumulatively considerable significant impact related to biological resources. (Less than Significant)**

The tree-thinning and vegetation removal is intended to provide a benefit to biological resources and would not contribute to long-term, adverse cumulative impacts on sensitive species and habitats. Implementing the proposed project is expected to be beneficial and would increase the amount and variety of wildlife habitat, would improve habitat connectivity and biodiversity, would reduce non-native and invasive vegetation, and would increase native vegetative cover.

Other future foreseeable cumulative projects in the area include the Significant Natural Resource Areas Management Plan (SNRAMP) proposed by the San Francisco Recreation and Park Department (SFRPD). The SNRAMP is intended to guide natural resource protection, habitat restoration, trail and access improvements, other capital projects and maintenance activities over the next 20 years in 31 natural areas in San Francisco and one in Pacifica. As discussed under the Project Description, the approximately 16.5 acre Interior Greenbelt area is owned by the City of San Francisco and is located just east of the Reserve. The Interior Greenbelt is one of the natural areas identified in the SNRAMP. The SFRPD proposes specific management actions in the SNRAMP within the Interior Greenbelt. The management actions would focus on native tree planting and restoration, reducing invasive plants and trees and trail improvements. In combination with the SNRAMP, the cumulative projects proposed to occur within the project vicinity could have potentially significant adverse impacts on biological resources over both the short-term and the long-term. However, the goal of the proposed project and the SNRAMP is to preserve and maintain open space in the region and the mitigation measures identified previously in this section would be implemented to protect biological resources; as a result, the proposed project would not result in a cumulatively considerable adverse impact on biological resources. Overall, the proposed project and the SNRAMP would add to these beneficial effects and the potential cumulative long-term impacts on biological resources associated with the proposed project would not contribute to cumulative adverse impacts related to biological resources.

**Mitigation:** None required

## 4.3.7 REFERENCES

LSA. 2011. *Biological Resources Report, Mount Sutro Open Space Reserve, San Francisco CA.*

# 4.4 CULTURAL RESOURCES

## 4.4.1 INTRODUCTION

A cultural resources report[1] was prepared to determine whether the Reserve qualifies as a historic resource (i.e. meets the California Register of Historical Resources criteria), and to determine whether the proposed management activities would have a significant impact on a historic resource. Information from the report, which is included in Appendix D of this EIR, is summarized in this section. Impacts associated with the proposed project are compared with the thresholds of significance adopted by the California Environmental Quality Act (CEQA).

## 4.4.2 ENVIRONMENTAL SETTING

### Background

The approximately 61- acre Reserve is located at the UCSF Parnassus Heights campus site, adjacent to and including Mount Sutro. In 1973, The Regents of the University of California designated the Reserve as permanent open space that is open to the public. A portion of the City of San Francisco's Interior Greenbelt abuts the Reserve on its eastern edge and the two areas are physically and visually contiguous. The Interior Greenbelt is managed as part of the Department of Recreation and Parks' Natural Areas Program. An additional section of the Interior Greenbelt is located on the south side of Clarendon Avenue in the vicinity of the Sutro Tower. The Reserve also abuts private property on its west side.

The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and other plants and replacement with native species.) Vegetation management actions are proposed to occur throughout the Reserve over many years and would be phased beginning with four demonstration projects that were crafted during the community planning process. The first three demonstration projects would be implemented following completion of environmental review and project approval. The fourth demonstrations project would be implemented approximately one year after the first three demonstration projects. The proposed management activities and the detailed description of the demonstration projects are discussed in Chapter 3, Project Description.

Within the framework of cultural resources analysis, Mount Sutro can best be described as a cultural landscape.[2] Whether this cultural landscape qualifies as a historical resource under CEQA is evaluated later in this section. For purposes of this analysis, the "Mount Sutro Cultural

[1] Denise Bradley, ASLA and Knapp & VerPlanck Preservation Architects, *Final Mount Sutro Open Space Reserve Cultural Landscape Evaluation Report*, October 3, 2011; revised January 10, 2013.

[2] Cultural landscapes are considered to be geographic areas shaped by human activity; they can result from a conscious design or plan, or evolve as a byproduct or result of people's activities; and they may be associated with a historic event, activity, or person or exhibit other cultural or aesthetic values (NPS 1996, 4).

Landscape Study Area" refers to the 61-acre Reserve that is owned and managed by UCSF, and the 12-acre portion of the Interior Greenbelt adjacent to and contiguous with the east side of the Reserve that is owned and managed by the City and County of San Francisco. However, no intensive survey of the Interior Greenbelt was conducted for the cultural landscape evaluation, as it is outside the Reserve boundaries and beyond the jurisdiction of UCSF. Nonetheless, the Interior Greenbelt is considered part of the Mount Sutro Cultural Landscape Study Area in this analysis.

## 4.4.2.1 HISTORIC CONTEXTS

### Overview of Afforestation in California and San Francisco

A key influence in the creation of the Sutro Forest[3], which includes the Mount Sutro Cultural Landscape Study Area, was late nineteenth-century afforestation practices that viewed planting trees as a way to address concerns over a diminishing resource and as a way to improve the land. The importance of trees was partly based on the ideals of the romantic park design during this era and the urgent desire to protect forest and timber resources that had become a national and state focus in the 1860s. Mass tree plantings were undertaken throughout California and locally in San Francisco during the last decades of the nineteenth century. In 1865, a paper was prepared by Reverend Frederick Starr who predicted that a timber famine would occur within 30 years and advocated the management of forests, establishing plantations, especially hardwood trees. This paper played an important role and became an impetus of the forest movement that eventually founded the U.S. Forest Service. It also began the development of the "Eucalyptus Boom in California."[4]

The massive immigration to California after the discovery of gold in 1849 resulted in an increased demand for lumber (for building material) and for firewood (the primary fuel for heating and cooking), and as a result, the state's forests were cut indiscriminately to provide for these needs. The state legislature passed a timber protection law in 1862 that prohibited cutting trees on both private land and public streets. The federal government also promoted tree planting; a federal law was passed in 1873 that gave 160 acres to anyone who planted 40 acres of trees and maintained them for eight years. During this era, tree planting was a popular philosophy that advocated afforestation for a wide variety of benefits. By the late 1860s, tree planting had come to be viewed as a patriotic duty throughout the country.

### Development of Stern Grove, Golden Gate Park and the Presidio Forest

During the last three decades of the nineteenth century, large areas of San Francisco were planted with trees on what had previously been sand dunes or unforested hillsides. The new forests

[3] In 1886, Adolph Sutro began a massive tree planting effort within the 1,200-acre San Miguel Rancho parcel that resulted in what became known as the Sutro Forest; the forested area on Mount Sutro was originally part of Sutro Forest. Refer to Section 4.4.2.1: Adolph Sutro's Role in Shaping the San Francisco Landscape and Section 4.4.2.2: Adolph Sutro and the Sutro Forest for more information.

[4] Gayle Groenendaal, "*History of Eucalypts in California: Eucalyptus Helped Solve a Timber Problem, 1853-1880*" (1983), page 2.

dramatically changed the city's western edge, from the Presidio of San Francisco to the Ocean Avenue area to the south. The trees at Stern Grove, Golden Gate Park, and in the Presidio are all examples of this late-nineteenth-century, large-scale, tree-planting efforts of which portions continue to survive today. Their history provides valuable comparisons and contrasts to the development of the Sutro Forest and the Mount Sutro Cultural Landscape Study Area.

**Stern Grove**

The forest at Stern Grove represents one of the earliest eucalyptus plantings in San Francisco. In 1847, George M. Greene came to California from Maine and staked claim to 160 acres within the vicinity of present-day Sloat Boulevard and 19th Avenue. Later, Greene's holdings expanded by 25 acres to include present-day Stern Grove and Pine Lake Park. Greene's two brothers soon arrived in California and the three of them owned the land from the Stern Grove vicinity west to the ocean. The Greenes were part of the early Anglo-American community that developed in San Francisco's Outside Lands area (today's Parkside District) after the United States took control of California from Mexico in 1846. Due to the constant winds and shifting sands blowing across their land, the Greenes planted eucalyptus trees as wind breaks and to anchor the shifting sand dunes on their property. As with other forest planting efforts in San Francisco during the late 19th century, Greene planted eucalyptus, Monterey cypress, Monterey pines and "Holland grass" to help stabilize the sand dunes. Today, this forest continues to exist on the slopes that encircle the park. The trees continue to be a character-defining feature of this part of the city and have been identified as a contributing feature to the Stern Grove and Pine Lake Park National Register of Historic Places (NRHP)-eligible historic district.

**Golden Gate Park**

Golden Gate Park is a 1,017-acre urban park in the western section of San Francisco. It stretches 3.5 miles from the center of the city, west to the Pacific Ocean. San Francisco acquired the land for Golden Gate Park in the late 1860s as a part of the 1865 settlement of the ownership of the Outside Lands (land west of the city's original 1851 charter). The Golden Gate Park site was one of three potential sites that were actively promoted during the 1860s for a major park development (the other two were the Presidio and the area south of the city core known as Mission Valley). In 1871, William Hammond Hall began development of the park. Hall conceived a plan to stabilize the dunes and plant trees based on principles he gathered from writings on similar situations in Europe and North Africa. Hall also visited Central Park, Prospect Park (in Brooklyn), Fairmount Park (in Philadelphia) and Druid Hill Park (in Baltimore) and adapted the ideas reflected in these parks to the Golden Gate Park site.

During the park's critical first five years, Hall successfully laid out the key components of his design, reclaimed sand dunes and established the park's forests. Within three years, Hall set out over 66,000 trees, with eucalyptus, Monterey cypress, and Monterey pine being the three predominant species planted. In only two years, eucalyptus seedlings shot up to eighteen feet with a caliper of four inches. Monterey pines and Monterey cypress reached fourteen feet with a spread of ten to twelve feet during the same period. He planted trees closely so they would

support each other against the buffeting winds; the trees would later be thinned as they matured. By the end of the decade, the park featured two miles of roads and paths and more than 135,000 trees and shrubs had been planted. By 1886, the park faced problems associated with the thickly-planted stands of trees that had not been thinned as Hall had envisioned. The park is listed on the NRHP and is historically significant under NRHP.

**Presidio Forest**

The sand dune reclamation and tree-planting methods used by William Hammond Hall's seminal 1871 plan for Golden Gate Park was influential to the development of the forest within the Presidio of San Francisco and likely also influenced Adolph Sutro's plantings at Mount Sutro. The conditions at the Presidio were similar to those at Golden Gate Park. Similar to Golden Gate Park, the design for the Presidio Forest has its roots in the practice of large-scale afforestation efforts that were underway in California during the late nineteenth century and in the romantic park design principles of this era that is applied to the mass planting of trees.

Major William A. Jones, a member of the U.S. Army Corps of Engineers, developed the "Plan for the Cultivation of Trees upon the Presidio Reservation" in 1883. It provided the rationale and blueprint for the development of the Presidio Forest. Jones ideas and concepts at the Presidio were likely inspired and guided by Hall's plan for the Golden Gate Park. By 1883, Golden Gate Park's plantings were well-established, and the design was generally considered a success.

The Presidio Forest was designed based on Jones' 1883 plan. The critical period for the implementation of the 1883 plan was between 1886 and 1895 when the general location of the forest and its overall character-defining features were established. A second phase of development occurred between 1902 and 1906 as described in the 1902 report *Plan for the Improvement and Extension of the Forest on the Military Reservation of the Presidio of San Francisco*, prepared by Hall. In 1902, Hall studied the 420-acre Presidio Forest which was developed based on the ideas and vision presented in Jones' 1883 plan, and provided his analysis—as a forester—on the Presidio Forest's existing conditions.

Major Jones was transferred before planting began at the Presidio. The full range of tree and shrub species included in Jones' 1883 plan was never planted. Instead, a narrow range of evergreen species were planted that were readily available in California at the time that had proved hardy and adapted to the site conditions when used at Golden Gate Park. These species included blue gum eucalyptus, Monterey cypress, Monterey pine and Blackwood acacia.

The development of the Presidio Forest was impacted by a lack of professional oversight. The planting density and the lack of tree thinning and pruning caused an overcrowded growing environment that resulted in low light conditions that contributed to the limited establishment of understory vegetation. These are some of the problems within the present-day forest, and which are similar to the conditions and problems facing the forest at Mount Sutro.

## Mount Sutro's Association with Late 19th Century Afforestation in California

### Key Species and Techniques Used in San Francisco Afforestation Efforts

Blue gum eucalyptus, Monterey cypress and Monterey pine dominated the tree planting efforts in San Francisco. Hall's oversight of the development of Golden Gate Park during 1871-1876 established that these trees grew quickly, were able to withstand local site and climate conditions and were suited to the goals and techniques of the late-nineteenth century afforestation process.

Monterey cypress and Monterey pine were native California species that were adapted to the environment along the California coastline. Monterey cypress was the favorite species for use in windbreaks along the California coast due to their ability to thrive in areas drenched in moisture from summer fog. Although native to California, Monterey cypress occurred naturally only on the Monterey Peninsula in two localized groves; however, by the early twentieth century, they were the most-widely-grown cypress in California. John McLaren, the superintendent of Golden Gate Park and one of the foremost horticultural authorities in the state, wrote in 1908 that the Monterey cypress "makes an excellent wind-break and stands exposure as well as, if not better than, any tree we have experimented with [at Golden Gate Park]."[5]

Lupine (a native plant) and other nonnative brushy plants were planted to stabilize the sand dunes in Golden Gate Park, the Presidio and throughout the Sutro Forest. Then the major fast-growing species (eucalyptus, Monterey cypress and Monterey pine) were planted closely together so that they would support each other against the buffeting winds. For example, during the first Arbor Day plantings at Yerba Buena Island, Adolph Sutro recommended planting the trees two to three feet apart.[6] This planting technique assumed that some trees would die and the ones that survived would later be thinned as they matured.[7]

### Eucalyptus in California

---

[5] John McLaren, *Gardening in California, Landscape and Flowers*, 3rd edition (San Francisco, CA: A.M. Roberson, 1908, revised 1914 and 1924), page 93.

[6] San Francisco Chronicle, "Arbor Day" (September 11, 1886), page 4.

[7] Russell Beatty described William Hammond Hall's experiences in 1871 in establishing the plantings in Golden Gate Park in "The Planting of Golden Gate Park: A Metamorphosis in Sand" in *The Trees of Golden Gate Park and San Francisco*: "In only two years, eucalyptus seedlings shot up to eighteen feet with a caliper of four inches. Monterey pines and Monterey cypress reached fourteen feet with a spread of ten to twelve feet during the same period. He adopted an intelligent planting scheme, planting the trees closely so that would support each other against the buffeting winds; the trees would later be thinned as they matured" (page 7). Hall wrote about these practices in *The Development of Golden Gate Park and Particularly the Management and Thinning of Its Forest Tree Plantations*, his 1886 report to the San Francisco Board of Park Commissioners, and explained that "[t]he planting of trees was done in the expectation that full twenty-five percent might fail to grow" (page 10) and that "this practice of planting thick, and afterwards thinning as the young trees commence to interfere with each other, in varied degrees, is a universal custom in the cultivation of forest growths" (page 11). He went on to explain that at Golden Gate Park "trees were planted four to eight feet apart, in1871 to 1876, with the view of gradually cutting out full two-thirds of the number within the years down to this time [1886]" (page 13).

*Eucalyptus* is native to Australia and has over 600 species. It has adapted to a variety of growing conditions and has been planted all over the world for its wood and its oil, as a windbreak to protect crops and settlements, and as an ornamental plant. The nonnative eucalyptus became the species most closely identified with the late nineteenth century afforestation efforts and became widespread in the California landscape. Botanists and other enthusiasts promoted eucalyptus as the perfectly suited tree as an answer to concerns around the loss of the state's forests because of their immense size, rapid growth rate and adaptability to a wide range of growing conditions.

During the late nineteenth and early twentieth centuries there was an increase in eucalyptus planting in California, referred to as the "Eucalyptus Boom." There were two eucalyptus booms in California. The first boom occurred during the last two decades of the 1800s and was tied to the need for a ready source of wood and established eucalyptus as a part of the California landscape. The second wave of planting occurred between 1905 and 1912 and was driven by economic speculation in eucalyptus plantations. During the first boom, eucalyptus trees were promoted by a wide range of interests. The railroads played a key role in spreading eucalyptus trees throughout the state. In January 1877, both the Central and Southern Pacific Railroads announced intentions to plant eucalyptus trees all along their respective rail lines. Southern Pacific planted 190,000 trees along the Los Angeles tracks, and between 1877 and 1879, Central Pacific planted about 1,000,000 eucalyptus trees. The railroads were interested in eucalyptus because the trees grew quickly, adapted to harsh growing conditions and could provide wood needed to repair rail lines. However, the railroads soon abandoned the use of eucalyptus wood for rails when it proved to be too brittle. Public agencies also contributed to the spread of eucalyptus throughout the state by providing incentives such as free seedlings or paying a premium for planting the trees. Eucalyptus was widely planted in parks and as street trees during the late nineteenth century. By the end of the nineteenth century, eucalyptus could be seen almost anywhere in the state where the climate permitted. Although eucalyptus wood was not suitable for building materials, it was still in vogue during the period when the Sutro Forest plantings were underway in 1886 to 1898.

The second eucalyptus boom occurred between 1905 and 1912 and is not directly related to the historic context for the development of the Sutro Forest. This second boom was influenced by the fears associated with disappearing forests. A 1907 report written by William L. Hall suggested that softwood, metal and concrete would be used in place of hardwoods in the future. While the first eucalyptus boom was based on the fascination with the botanical characteristics and a belief that tree planting was needed in California, the second wave was fed by speculation. In 1911, eucalyptus nurseries in California produced 7,500,000 seedlings. This interest was short-lived when it became clear the beneficial claims promoted about eucalyptus could not be substantiated. An estimate of 40,000 and 50,000 acres of eucalyptus were planted during the second boom.[8]

[8] Woodbridge Metcalf, *Growth of Eucalyptus in California Plantations*, University of California Publications, College of Agriculture, Agricultural Experiment Station, Berkeley, California, Bulletin No. 380, November 1924 (Berkeley: University of California Printing Office), page 6.

## Adolph Sutro's Role in Shaping the San Francisco Landscape

Adolph Sutro was born on April 29, 1830 in Prussia where his father was a prosperous cloth merchant. He left school at 16 to work as the superintendent at his father's factory. After his father died in 1847 and the revolution that spread through Europe in 1848, Sutro along with his mother and 10 siblings immigrated to the United States, arriving in New York City in August 1850, ultimately settling in Baltimore. Sutro soon left his family and arrived in San Francisco on November 1851. For the next nine years, he made his living as an importer of general merchandise. During this period he married and started a family.

In 1860, Sutro left for Virginia City, Nevada for the silver mines. In the late 1860s and 1870s, Sutro made his fortune in the design and construction of a massive tunnel that drained and ventilated the flooded shafts of the Comstock Lode silver mines in Nevada. The construction of this tunnel provided the basis for countless fortunes in silver and was also recognized as having significantly improved the health, safety and working conditions for the miners. This combination of ingenuity and benevolence characterized Sutro's later work in San Francisco.[9]

After Sutro was forced out of the tunnel company in the 1870s, he sold his stock and invested in San Francisco real estate. At one point, Sutro owned 2,200 acres in San Francisco. His holdings equaled one twelfth of San Francisco's entire land area.[10]

Although Sutro purchased a significant amount of downtown property, his efforts were focused largely in the Outside Lands area. Sutro was the force that transformed the character of this part of the city. Sutro's single largest land acquisition was his 1880 purchase of a 1,200-acre parcel for $520,000, the remnant of the 4,400-acre Rancho San Miguel. The parcel ran from the present-day UCSF Parnassus Heights campus south along Stanyan Street, up over Twin Peaks running due south (aligning roughly with present-day Gennessee Avenue) to the Ocean View district, then east to Junípero Serra Boulevard and north to Laguna Honda. The ranch contained the four peaks of the San Miguel Hills—Mount Sutro, Twin Peaks and Mount Davidson. In 1886, Sutro began a massive tree planting effort within this 1,200-acre parcel that resulted in what became known as the Sutro Forest; the forested area on Mount Sutro originated with this effort. The forest planting is described in more detail below, in Section 4.4.2.2., Evolution of Mount Sutro. Although the origins of this planting were undoubtedly influenced by contemporary landscape ideals and forestry concerns, Sutro's ultimate plan for Sutro Forest is not known. The completion of the Twin Peaks tunnel in 1918 connected this area to the city's core and ignited the growth in the San Miguel rancho lands during the early twentieth century.

The development of the forest ended with Sutro's death in 1898, and the legal battle over his estate kept the 1,200-acre Rancho San Miguel tract and the Sutro Forest intact for over a decade. When development began in 1912, the neighborhoods that were carved out of the 1,200-acre parcel looked very different from the rest of the city. With no property owners, structures, streets, or facilities to move or condemn, the forested hillsides provided a perfect template for the

[9] Land and Community Associates 1993 in Bradley and Corbett 1999, page 104.
[10] Some secondary accounts state Sutro's holdings equaled one tenth of the city's area.

implementation of the Garden City movement which called for residential parks with detached houses, villa-sized lots, landscaping, curvilinear streets and the segregation of commercial buildings.[11] Under this movement, St. Francis Wood and Forest Hill were the first neighborhoods to be developed on the rancho site. Ultimately, Forest Knolls, Midtown Terrace, Sherwood Forest, Monterey Heights, Westwood Highlands, Westwood Park, Balboa Terrace and Mount Davison Manor were developed on the former Sutro land. Sutro's control of this large area and his heirs' inability to resolve their differences for so many years prevented piecemeal development and contributed inadvertently to the shaping of the neighborhoods in the western part of the city.

In 1881, Sutro purchased a little over 100 acres of land at Point Lobos overlooking the Cliff House and Seal Rocks. Sutro also acquired an adjacent property that was a little over 21 acres, as well as 80 acres of shore lands bordering Fort Miley and part of the future Lincoln Park, which included the Cliff House. Between Sutro's 1881 purchase of the property and his death in 1898, he was intimately involved in the development of Sutro Heights into one of the most impressive Victorian gardens in the country, the construction of the Sutro Baths, rebuilt the Cliff House as a chateau-style palace and built a passenger railroad that provided an inexpensive means for the public to reach these facilities from downtown to Point Lobos.

During the early 1880s, Sutro became a serious book collector whose ultimate goal was to "form a collection with sufficient range and depth across different branches of human knowledge and periods of history that it might serve as the basis for a leading public research library on the Pacific Coast."[12] Within ten years, he had assembled the largest private library in America. Sutro initially planned to locate his library at Sutro Heights due to the beauty of the site. However, he abandoned this plan after experts advised him that the salt air at Point Lobos would damage his collection. Instead, he decided on a 26-acre tract on the north side of Mount Sutro along Parnassus Avenue. Sutro chose this site for his library because it was at the geographical center of the city and could serve many generations to come. The site's level plateau was appropriate for construction and was protected by hills which he believed would protect the collections from fires. He believed the setting at Mount Sutro (or Mount Parnassus, as he called it), with a forest of pines, cypress and acacias would form a beautiful background for the buildings and would inspire scholars to higher achievements.[13]

Sutro's desire to locate the library on this parcel coincided with the University of California's effort to establish a new campus in San Francisco to house its schools of law, medicine, pharmacy and dentistry (or what were later termed the "Affiliated Colleges"). Sutro offered to deed the western half of the acreage to the University of California. The Regents accept Sutro's offer in October 1895 and the present day Parnassus Heights campus opened in October 1898. However, Sutro's library was never built, and the vision of a library located on the north side of Mount

[11] Richard Brandi, Farms, F*ire and Forest: Adolph Sutro and Development West of Twin Peaks*, The Argonaut, Vol. 14 No. 1 Summer 2003, pages 36-49.
[12] Russ Davidson, *Adolph Sutro As Book Collector: A New Look*. California State Library Foundation Bulletin No. 75 (Spring/Summer 2003): pages 2-27.
[13] Adolph Sutro's Letter to the Regents of the University of California and to the Committee of Affiliated Colleges on the Selection of a Site for the Affiliated Colleges; 1895; n.p.

Sutro died with Sutro. Adolph Sutro died in August 1898 at the age of 68, shortly after serving one term as mayor of San Francisco (1895-1896).

## 4.4.2.2 EVOLUTION OF MOUNT SUTRO

Cultural landscapes are defined as geographic areas shaped by human activity. They can result from a conscious design or plan, or evolve as a byproduct or result of people's activities. They may be associated with a historic event, activity, or person or exhibit other cultural or aesthetic values.[14] This chapter provides a summary of historic events and their impact on the evolving character, appearance, and features of Mount Sutro.

### Pre-Contact Landscape

Before the European discovery of the San Francisco Bay, the land south of the Golden Gate (from the San Francisco Peninsula to the East Bay and south to Monterey) was part of the aboriginal lands of the Ohlones, also called *Costanoans* by the Spanish. In the late 1700s, at the time of the Spanish occupation, approximately 1,400 Ohlone organized into a number of small, politically independent societal groups or tribes and lived in the San Francisco and San Mateo area. Groups moved annually between temporary and permanent village sites in a seasonal round of hunting, fishing and gathering. Ethno-history suggests that small villages were maintained along the San Francisco peninsula shoreline and marshlands, and it was these activities within the Ohlone's cultural beliefs and values that shaped the cultural landscape of the San Francisco peninsula. The Ohlone population and their traditional life ways—and this pre-contact cultural landscape—were altered by the Spanish colonization and the mission system.

### Spanish and Mexican Period (1776-1846)

In the late eighteenth century, the Spanish expanded their empire into Alta California. Juan Bautista de Anza established a route from Mexico to California in 1774. In 1776, Anza led 240 people, from Tubac, Mexico to San Francisco, in order to establish a permanent settlement.

There were three components to the Spanish settlement in San Francisco. *El Presídio de San Francisco*—located in the vicinity of today's Presidio was in a protected area close to safe anchorage by the Bay. This site housed the Spanish garrison and supported the administrative and training operations. To the northwest overlooking the Golden Gate, the Spanish established the *Castillo de San Joaquín*, in the location of present-day Fort Point, to guard the entry to the Bay. Several miles southeast of the Presidio, the Spanish built *Misíon San Francisco de Asís* (now known as Mission Dolores) in a location with access to fresh water supply. The Mission was protected by the Presidio and in turn supplied the garrison stationed there with food.

In 1820, Mexico achieved its independence from Spain and California came under control of the Mexican government. Military and religious power was transferred to secular administrations.

[14] National Parks Service, *Secretary of the Interior's Standard for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes* (1996), page 4.

Mission secularization began in 1822 but did not occur in Alta California until 1833. Mission lands and properties were either taken over by the State, sold, or granted to loyal Mexican citizens and native-born inhabitants of Spanish descents. In 1834, the California missions were secularized, and the majority of the mission lands were removed from Franciscan control. Subsequently, the Mexican government issued large land grants designed to support the cattle grazing that supplied Mexico with tallow and hides. In 1845, José de Jesus Noe received a land grant of over 4,400 acres, known as *Rancho San Miguel*, it comprised one-sixth of San Francisco.

Mount Sutro is located on land that was part of the original Mission Dolores landholdings that were subsequently included in Noe's grant, although its boundary cut diagonally across the northwest side of the peak. The Spanish and Mexican impact on the Mount Sutro landscape was limited to the alteration of vegetation communities by the livestock grazing. It is likely that Mount Sutro was part of the land used by the Mission to graze cattle. Similarly, Noe ran 2,000 head of cattle on this land. During this period Mount Sutro was likely covered with coastal scrub vegetation, consisting of native grasses and low to medium-sized shrubs. Historic photographs from the mid-nineteenth century do not show trees on the peak. If there were any, such as native oaks or California bay, they were likely in the protected ravines on the lower slopes.

## American Period (1850-1880)

California became part of the United States in 1846 when it was conquered during the Mexican War. In 1850, California became the 31st state. Like many Mexican ranchers, Noe had difficulty keeping his land holding after California became a part of the United States. He began selling it piece-by-piece in 1848. The eastern part of the rancho was developed as early as the late 1800s, creating the residential neighborhoods of Noe Valley, Eureka Valley and Fairmont Terrace. The portion of the rancho west of Twin Peaks remained open and sparsely settled. Settlement was hindered first by the long dispute between the City of San Francisco and the federal government over the ownership of the lands outside of the city's charter line of 1851 (lands west of Divisadero Street known as the "Outside Lands") and then after 1865, following the settlement in favor of the city, by geography—its distance from the city's center and the barrier of the San Miguel Hills. San Franciscans thought of the area west of Twin Peaks as rural and remote.

This early American period had little if any impact on Mount Sutro. On an 1873 city map, the peak was not labeled and was not identified as a landmark or destination as it would be by end of the nineteenth century, after the development of the Inner Sunset on its east, north and west sides and after Sutro planted the forest. A broad swath of this 1873 map along the interior (including Mount Sutro) is simply shown as blank and was identified as the "San Miguel Rancho."[15] The land changed hands several times until Adolph Sutro purchased the 1,200-acre tract that was the remnants of the original 4,400-acre grant in 1880.

[15] A. L. Bancroft & Company, *Bancroft's Official Guide Map of the City and County of San Francisco . . .* (San Francisco: A. L. Bancroft & Company, 1873); Sally B. Woodbridge, *San Francisco In Maps & Views*. (New York: Rizzoli International Publications, Inc., 2006), page 80.

## Adolph Sutro and the Sutro Forest (1880-1898)

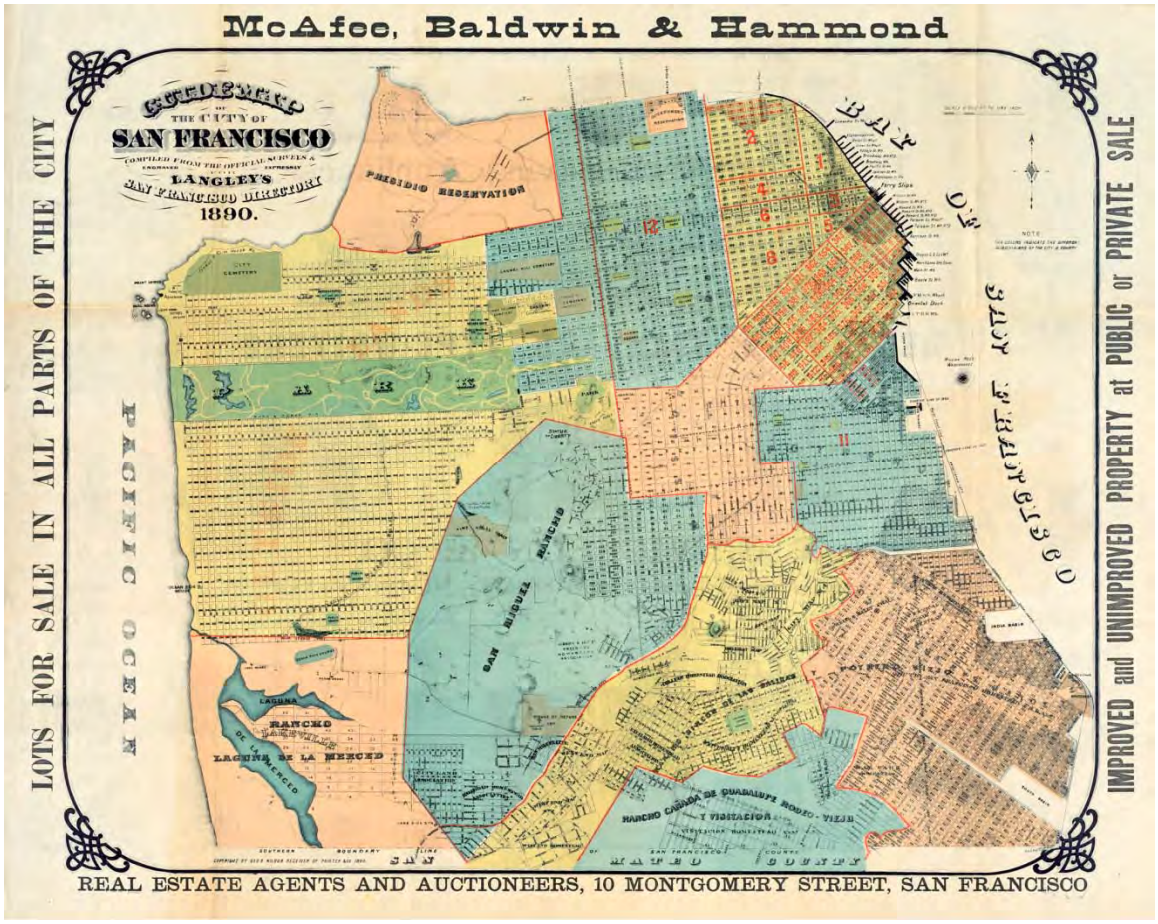
Adolph Sutro invested in real estate in San Francisco after he sold his stocks in the silver mining company in Nevada. While he purchased significant amount of property downtown, Sutro's largest single acquisition was the 1,200-acre San Miguel Rancho parcel, which ran from the present-day UCSF Parnassus Heights campus south along Stanyan Street, up Twin Peaks to the Ocean View district, east to Junipero Serra and north to Laguna Honda (see Figure 4.4-1). The establishment of the Mount Sutro forest was part of Sutro's larger forest planning efforts on the 1,200-acre San Miguel Rancho parcel – in what came to be known as the Sutro Forest -- that began in 1886. The main species for the new forest were eucalyptus, Monterey cypress and Monterey pine which he supplemented with ash, beech and other species that for a number of reasons failed to get established. There were various large-scale, tree-planting efforts were underway throughout San Francisco, although the effort for Sutro Forest (which included tree-planting on Mount Sutro) would be the largest.

In an 1896 article, it was cited that Sutro forest contained from 1,100,000 to 1,200,000 trees. The trees were planted very close together based on assumptions that this would provide the young trees protections from the elements while the stands were getting established and the stands would ultimately be thinned out to a lower density. However, even with tree thinning, the forest growth was so rapid that by 1896, many trees were 85 to 100 feet in height with trunks measuring one to two feet in diameter. By 1910, the forest was described as being almost impenetrable in places and another major thinning operation was undertaken in 1909.

In addition to tree planning, Sutro constructed a trail around the summit of Mount Sutro. Plans for the trails have not been located. However, various references to these trails appeared in early 1900s articles. The trails remained after Sutro's death and provided public access onto the property, helping to develop a local constituency for Mount Sutro as a public natural area. The forested slopes of Mount Sutro appear to have figured prominently in his plans for the library and it is possible that the trail system may have been developed in anticipation of the library.

## Control of Mount Sutro by Sutro's Heirs (1898-1953)

Adolph Sutro died on August 8 1898 at the age of 68. His estate was valued at $3 million. His daughter Emma Sutro Merritt served as the executrix of his estate. She had the property appraised and found the estate to be deeply in debt and she did not have the financial resources to maintain the extensive facilities her father had established (the second Cliff House, Sutro Baths, Sutro Heights and Sutro Forest). Sutro's heirs battled over the terms of his will and the fate of the estate for over two decades. A court decision allowed the sale of the 1,200-acre Rancho San Miguel tract and Sutro Forest in 1909. It was around this time that the peak was officially named Mount Sutro.




Source: David Rumsey Maps

**Figure 4.4-1**
Langley's 1890 Guide Map to the City of San Francisco
San Miguel Rancho tract shown in blue in the center

In the division of the estate, one of Sutro's daughters received the 90 acres of the Forest Tract that included Mount Sutro (the area between Parnassus and Clarendon Avenues) and another 90-acre tract that included the southern and southwestern slopes of Mount Sutro (where Forest Knolls was ultimately constructed in the late 1950s) was inherited by his other daughter, who subsequently willed the land to the Littler Sisters of the Poor.

The forest was described as wilderness where coyotes, foxes, wildcats and other wildlife could be found. Even though a caretaker lived in the vicinity of Mount Sutro to patrol the forest, discourage trespassers and to keep a lookout of fires, the vegetation within Mount Sutro was impacted by the intermittent fires and by the vegetation thinning that occurred in 1909. The Sutro heirs tried to find ways to limit public access because of the fires but the public continued to use the forest for hiking, camping and hunting. In additional, the causal recreational use by the public likely resulted in the development of social trails throughout the Mount Sutro landscape.

A 1930 map showed an unpaved trail that encircled the peak (likely what is identified today as the "Historic Trail") and another road along the lower reaches of the south and west slopes. The developing neighborhoods to the east, north and west provided a distinctive contrast to Mount Sutro's forested slopes, and the extension of Clarendon Avenue west to 7th Avenue in 1932 created a definitive boundary along the south side; until then the forest on the peak's south side extended unbroken into the larger Sutro Forest. The most dramatic impact to the cultural landscape was the logging which occurred in the early 1930s. This operation ended in 1934 after a fire burned 10 acres that required 400 firemen to extinguish. An aerial taken in 1935 shows the extent of the logging operation and how all the trees were clear-cut across the entire south half of the landscape (see Figure 4.4-2). A subsequent Works Progress Administration (WPA) project sacked and warehoused the left-over wood from this logging operation to supply families with stove wood; as part of this project certain areas previously logged were cleaned and burned.

## UCSF Period (1953-present)

In 1953, UCSF purchased the 90-acre Forest Tract from Sutro's heir. This began the development within the Mount Sutro Cultural Landscape Study Area and resulted in the addition of new buildings, reduction of the overall forested area and a redefined boundary.

The first noticeable alteration of Mount Sutro came with the construction of the northern half of the Medical Center Way alignment from Parnassus Avenue to the vicinity of the present-day Woods Lot, between 1948 and 1955 (see Figure 4.4-5). A rectangular section of the forest (roughly corresponding to the footprint of the present-day Woods Lot) was removed and a University-related facility was added on the east slope at the end of the new road. A smaller area was cleared on the uphill slope at the west end of the road to make way for a University-related water treatment facility. In 1954, the federal government leased four acres from UCSF and constructed the control center for Nike Battery SF-89 as part of the Bay Area's Nike missile defense system. The launch area for SF-89 was located at the Presidio. As part of the construction of the control center, the forest at the summit and a portion of the south slope were clear-cut, a road was laid out from Clarendon Avenue to the Nike structures at the summit. Nike Battery SF-89 was active from 1955 through 1963. After the nationwide Nike system was decommissioned in 1974, this site reverted back to UCSF. The Nike site was cleared and all of the buildings on the summit were removed between 1972 and 1977 and the summit was gradually invaded by woody shrubs.

Medical Center Way was extended south to Johnstone Drive between 1958 and 1961 as part of the construction of the Aldea housing complex. The southern side of Mount Sutro was dramatically altered by the construction of the Aldea complex. The 1961 construction of the Medical Center Way alignment bisected Mount Sutro and removed a portion of the Sutro-era trail. However, portions of it have since been rebuilt (today's Fairy Gate Trail), located to the east (or below) the road bed.

Source: HJW geospatial/Pacific Aerial Surveys

**Figure 4.4-2**
1935 aerial view of Mount Sutro showing extent of logging

In the late 1950s and early 1960s, the topography and the forest on the western and southwestern slopes of Mount Sutro were altered by the development of Forest Knolls. By 1958, the forest had been clear-cut and graded for housing development. As a result of this development, the boundary for Mount Sutro was redefined by the edge between the remaining forest and Christopher and Crestmont Drives, which were laid out as part of the Forest Knolls development. Remnants of the forest remain in Forest Knolls, on the slopes west of Crestmont and Warren Drives.

Other alterations to Mount Sutro occurred during the 1960s as part of the expansion of the UCSF. The Woods Building (100 Medical Center Way) was built along the east side of Medical Center Way in 1962. The Surge Building (99 Medical Center Way) was added just south of the Woods Building complex in 1966; the associated parking lot resulted in the removal of an additional portion of the forest. As noted earlier, in 1973, the 61-acre reserve was designated permanent open space accessible to the public by The Regents of the University of California. The forested area between the eastern boundary of the University-owned land and the residences along the west side of Stanyan Street historically was part of Sutro Forest, but is now owned by the City and County of San Francisco. The City's Interior Greenbelt is managed as part of the Department of Parks and Recreation's Natural Areas Program and abuts the Reserve on its eastern edge. The two areas are physically and visually contiguous.

### 4.4.2.3 EXISTING CONDITIONS WITHIN MOUNT SUTRO

Within the framework for cultural resources analysis, Mount Sutro can best be described as a cultural landscape. Cultural landscapes are defined as geographic areas shaped by human activity; they can result from a conscious design or plan, or evolve as a byproduct or result of people's activities; and they may be associated with a historic event, activity, or person or exhibit other cultural or aesthetic values.[16] There are four general types of cultural landscapes: historic sites, historic designed landscapes, historic vernacular landscapes, and ethnographic landscapes.[17] These types are not mutually exclusive and Mount Sutro has characteristics of both a designed landscape[18] and a vernacular landscape.[19] The California Register does not provide specific guidance for describing cultural landscapes. However, the California Register was consciously designed on the model of the National Register (the two programs are extremely similar, although there are areas in which these programs differ, and guidance provided in

[16] National Parks Service, *Secretary of the Interior's Standard for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes* (1996), page 4.
[17] NPS 1996, 4.
[18] A designed landscape is one that was consciously designed or laid out by a landscape architect, master gardener, architect, engineer, or horticulturist according to design principles. The landscape may be associated with a significant person, trend, or event in landscape architecture or may illustrate an important development in the theory and practice of landscape architecture. Aesthetic values tend to play a significant role in designed landscapes (NPS 1996, 5).
[19] A vernacular landscape has evolved through use by the people whose activities or occupancy shaped it, and as a result function plays a significant role in vernacular landscapes (NPS 1996, 5).

National Register and National Park Service publications were used in describing the existing conditions on Mount Sutro.[20]

As described in the National Register bulletins on cultural landscapes, the key processes to the formation of a cultural landscape include land uses and activities, patterns of spatial organization, responses to the natural environment and cultural traditions. The individual components of a cultural landscape include groupings of features within a larger landscape, circulation-related features, the various types of boundary demarcations, vegetation features, buildings and structures, archaeological resources and small-scale elements.

Individual features do not exist in isolation within a cultural landscape, but rather in relationship to the landscape as a whole, and it is the arrangement and the interrelationship of these character-defining features—as they existed during the period of significance that is critical to the significance of a cultural landscape. The importance of individual features to the development process may vary from landscape to landscape, and some features may be more important than others. In regards to Mount Sutro, the forest itself (its primary vegetation feature), the presence of trails (its primary circulation feature), the natural topographic characteristics of the site and the recreational land use are the character-defining features that have remained consistent since the late 1880s. This section provides a discussion of these character-defining features along with the other cultural landscape features that are present today.

## Land Uses

According to the National Register Bulletin 30, land uses are major human forces that shape and organize a cultural landscape. Land uses within the Reserve include the open space that provides natural habitat and recreational opportunities and the developed areas with University-related uses. Additionally, the lower slopes on Mount Sutro's west and south sides are developed with residential uses; the Interior Greenbelt along the eastern boundary of the Reserve provides natural habitat and recreational opportunities similar to those within the Reserve. These areas are outside the boundaries of the Reserve but were historically part of Sutro's land at Mount Sutro.

Adolph Sutro did not explicitly state his ultimate intent for the land use within the Sutro Forest. When initially planted, the forested area around Mount Sutro was private land but was informally used recreationally by the public, including hiking, picnicking and hunting. Sutro constructed a trail system around the peak, and in a letter he wrote to the Regents in 1895, with the offer to donate the western half of a tract along Parnassus Avenue for the Affiliated Colleges (see Figure 4.4-3), seems to indicate that he intended this trail system and the forest peak to have some type of public access in association with the college and his future library site. After Sutro's death, the forest at Mount Sutro remained nominally private property, with fences defining the boundary (see Figure 4.4-4), "no trespassing" signs, and a caretaker who lived on the site and

[20] Publications that were reviewed for guidance including *National Register Bulletin 18: How to Evaluate and Nominate Historic Designed Landscapes, National Register Bulletin 30: How to Evaluate and Document Rural Historic Landscapes,* and *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes.*

patrolled the area, but nonetheless continued to be used by the public. Today, the recreational and natural habitat land uses within the Reserve continue to provide a strong link to the historic land uses at Mount Sutro.

## Natural Features

The location of major natural features (such as mountains, prairies, rivers, lakes, forests and grasslands), climate, soils, and topography can influence both the location and organization of features within cultural landscapes.

At about 908 feet above sea level, Mount Sutro is the northernmost peak of the San Miguel range. The soils throughout the Reserve are relatively shallow and not rich in nutrients. Numerous outcrops of the underlying Franciscan formation cherts occur throughout the Reserve. Other than the summit area, over 60 percent of the Mount Sutro having slopes in excess of 30 percent.

Source: 1910 Appraisal of Sutro Estate

**Figure 4.4-3**
View of Affiliated Colleges and Mount Sutro
from Parnassus Avenue, circa 1910

Source: 1910 Appraisal of Sutro Estate

**Figure 4.4-4**
View of Mount Sutro from Stanyan Street looking south, circa 1910

The present-day steep slopes and exposed rock outcroppings are consistent with those encountered by Sutro when he began his planting. This topography influenced the layout of the trails, the growth of the forest and contributed to the perception of this area as a distinct area separate from the surrounding city. The height and topography of the peak provided panoramic views. However, with the growth of the trees, views are blocked or partially blocked.

Stanyan Canyon is located on the east side of the peak with Woodland Creek flowing through. Stanyan Canyon, the rocky ledges, steep terrain, and summit, were consistently mentioned as distinct geographical features in early twentieth-century descriptions of the Mount Sutro area. The steep terrain and the lack of street connections prevented the subdivision and development of this area. Changes that have occurred to these topographic characteristics include the ongoing failure of rock outcroppings where tree roots have penetrated and grown within the cracks; the leveling of the summit and the cut-and-fill to build the access road for the Nike site in mid-1950s; the loss of native soil when the Nike site and structures were decommissioned in the mid-1970s; and the grading that accompanied the construction of the University-related features (i.e., Medical Center Way, the Aldea complex, the Surge and Woods buildings and their related parking lots, the Chancellor's residence, and the water tanks and water treatment facility.) While

it's outside the boundaries of the Reserve, the west and south side lower slopes of Mount Sutro were dramatically altered in the late-1950s by the grading for the Forest Knolls neighborhood.

The concentration of rainfall during the winter months combined with the steep topography promotes runoff and erosion hazards on Mount Sutro. The site's coastal climate, combined with the sun exposure, the predominant direction of the wind, and the location of soils, results in three different microclimates. These microclimates explain some of the variation of the vegetation within the Reserve, the location of the remnant native plant communities and the condition of the vegetation. The north-facing slopes are less exposed to the sun, are exposed to predominantly northwest winds from the ocean, and retain the highest levels of humidity and moisture in the soil. Eucalyptus and other forest vegetation tend to be the most vigorous on the north and east facing slopes. Conversely, slopes facing south tend to be the warmest and driest. It is unlikely that Sutro took into account these microclimatic variations when he planted the forest, and the variations in the locations of vegetation, as a response to the microclimates, are related to the plant communities' adaptations to the site rather than to a conscious design.

## Boundary Demarcations

The Mount Sutro Cultural Landscape Study Area consists of the 61-acre Reserve that is owned and managed by UCSF and the 12-acre portion of the City-owned Interior Greenbelt that is adjacent to the east side of the Reserve. Historical accounts describe Stanyan Street as the eastern edge of the Sutro Forest. Although there is a legal boundary between these two areas, there is no visible boundary and the cultural landscape within the two is basically indistinguishable. Both the Reserve and this portion of the Interior Greenbelt were part of the original Sutro Forest planting. Today the visual boundaries of the Reserve are defined by circulation features and urban land uses that have developed around Mount Sutro since the forest was originally planted in the late nineteenth century.

The UCSF campus along Parnassus Avenue is located just north of the Reserve. Two streets, Koret Way and Medical Center Way and their related retaining walls define the visual edge along the north side of the Reserve. Residences along the west side of Edgewood Avenue and the Interior Greenbelt are located on the east side of the Reserve.

Residential uses on Clarendon Avenue, Christopher Drive and a short stretch of Crestmont Drive define the south edge of the Reserve. The UCSF Aldea Housing Complex and the Chancellor's residence are also located at the south end of the Reserve, outside of (and nearly surrounded by) Reserve boundaries. The roads, parking lots, and other hardscape features define the visual edge between the forest and the main core of the Aldea housing area. However, the forest blends seamlessly around the Chancellor's residence and the one Aldea housing unit (50 Johnstone Drive) located on the north side of Johnstone Drive. Crestmont Drive continues along the west side of the Reserve and defines the visual edge between the forest and the Forest Knolls neighborhood. The Kirkham Heights apartment buildings are located next to the northwest corner of the Reserve. The legal boundary for the Reserve is located several feet from the edge of Crestmont Drive.

## Spatial Orientation

Spatial organization refers to the patterns of space in a landscape. The organization of features in the landscape defines and creates spaces. The functional and visual relationships between these spaces within the landscape are integral to the historical character of a property.[21]

The trees planted by Sutro formed a contiguous forest. The experience within the landscape was one of open space defined by the natural topography and the stands of trees. There would have been both a sense of expansiveness due to the uninterrupted open space (i.e. lack of buildings and roads) and enclosure created by the towering trees. Today, Medical Center Way and Johnstone Drive cut through the forest and divides the landscape into two separate areas. Aside from the Medical Center Way/Johnstone Drive alignment and the pockets of built environment, the dominant spatial features of the Reserve is a contiguous forest with subareas created by the topography (i.e. the summit, Stanyan Canyon, etc.).

## Buildings and Structures

Cultural landscapes often contain various types of buildings and structures related to the occupation and use of the land. The distinction between the two is generally defined as buildings designed to shelter human activity, and structures designed for functions other than shelter. Only a limited number of structures are located within the Reserve. These include a small structure on the north side of Nike Road, a water tank located south of the summit and a water treatment facility and water tanks located off of Medical Center Way west of the Woods parking lot. The building on Nike Road may be a remnant of the Nike site, and the water tanks and treatment facility were added by the University between 1958 and 1961.

The Aldea housing complex, the Chancellor's residence, the Woods Building, and the Surge Building) are located within the Mount Sutro Cultural Landscape Study Area. However, the land around these buildings and their associated infrastructure are outside the legal boundary of the Reserve. The residential houses in the Forest Knolls neighborhood on the west and south slopes of Mount Sutro were carved out of the forest in the late-1950s and are also outside the boundaries of the Reserve. These structures are not associated with Sutro's development of Mount Sutro.

## Circulation Features

Circulation features include roads, parkways, drives, trails, walks, paths, parking areas and canals. Such features may occur individually or may be linked to form networks or systems. The character of circulation features is defined by factors such as alignment, width, surface and edge treatment, grade, materials and infrastructure. Circulation features in the Reserve are generally associated with the present-day recreational use of the Reserve or with UCSF. Additionally, there is one road associated with the prior use of the site by the Nike missile program.

[21] National Park Service 1996, page 15.

**Vehicular Routes**

Vehicular circulations within the Reserve include Medical Center Way, Johnstone Drive, Nike Road and two short access routes to the water tanks. These roads were constructed around the 1950s and 1960s and are not associated with Sutro's development of the cultural landscape.

**Pedestrian Routes**

There are several University-related pedestrian circulation routes within the Reserve. These include the following:

- A path along the east/north side of Medical Center Way provides a pedestrian route from the Aldea housing complex and the Surge and Woods buildings and parking lots to the main UCSF campus. It is an informal unpaved path between the Surge Lot area and the bus stop near the EH&S building and is paved with what resemble asphalt shingles between the Woods Lot and Johnstone Drive.

- Stairs and a paved path are located on the hillside west of the Surge Lot and provide access between this parking lot and the main campus area.

**Hiking Trails**

An unpaved trail system (generally two to three feet wide) within the Reserve provides access throughout the property and provides connections to surrounding streets. Figure 4.4-5 Existing and Proposed Trails shows the location of all of the trails except the Ishi Loop (which is not labeled in this figure). The trails located west of Medical Center Way include the following:

- The Upper Historic Trail provides access around the perimeter of the west and north sides of Reserve. It intersects with the South Ridge and Quarry Road Trails (on the south side of the Reserve) and Medical Center Way near the Woods Lot. The trailhead at Medical Center Way is across the street from the entrance to the Lower Historic Trail.

- The South Ridge Trail provides access within the southwest portion of the Reserve. Its north end intersects with the Nike Road and its south end loops around intersecting with the access trail from Christopher Drive as it runs past the Upper Historic and Quarry Road Trails.

- The West Ridge Trail provides access from Crestmont Drive on the west side of the Reserve up to the summit. It is maintained for emergency fire access by UCSF. This trail intersects the Upper Historic Trail and ends at Nike Road near the summit.

- The North Ridge Trail provides access between Medical Center Way and the summit along the north side of Mount Sutro. The trailhead at Medical Center Way is across the street from the entrance to the Fairy Gates Trail.

- The East Ridge Trail provides access between Johnstone Drive and the summit along the eastern ridge of Mount Sutro.

- The Mystery Trail connects the North and East Ridge trails along the north side of Mount Sutro.

The trails located east of Medical Center Way include the following:

- The Lower Historic Trail runs parallel to and below Medical Center Way for a short way before crossing the Edgewood Trail and heading east down through the Interior Greenbelt to the Stanyan Street trailhead.

- The Edgewood Trail originates at Edgewood Avenue in the Interior Greenbelt and leads south toward Woodland Creek, climbing up through Woodland Canyon and crossing the Lower Historic Trail to intersect with the Fairy Gates Trail.

- The west trailhead of Fairy Gates Trail is located across Medical Center Way from the North Ridge Trailhead. This trail runs parallel to and below Medical Center Way to connect to its east trailhead near the Chancellor's residence.

- The Belgrave Trail begins at the driveway of the Chancellor's residence and continues down the steep ridge on the southeast, into the Interior Greenbelt to Belgrave Avenue.

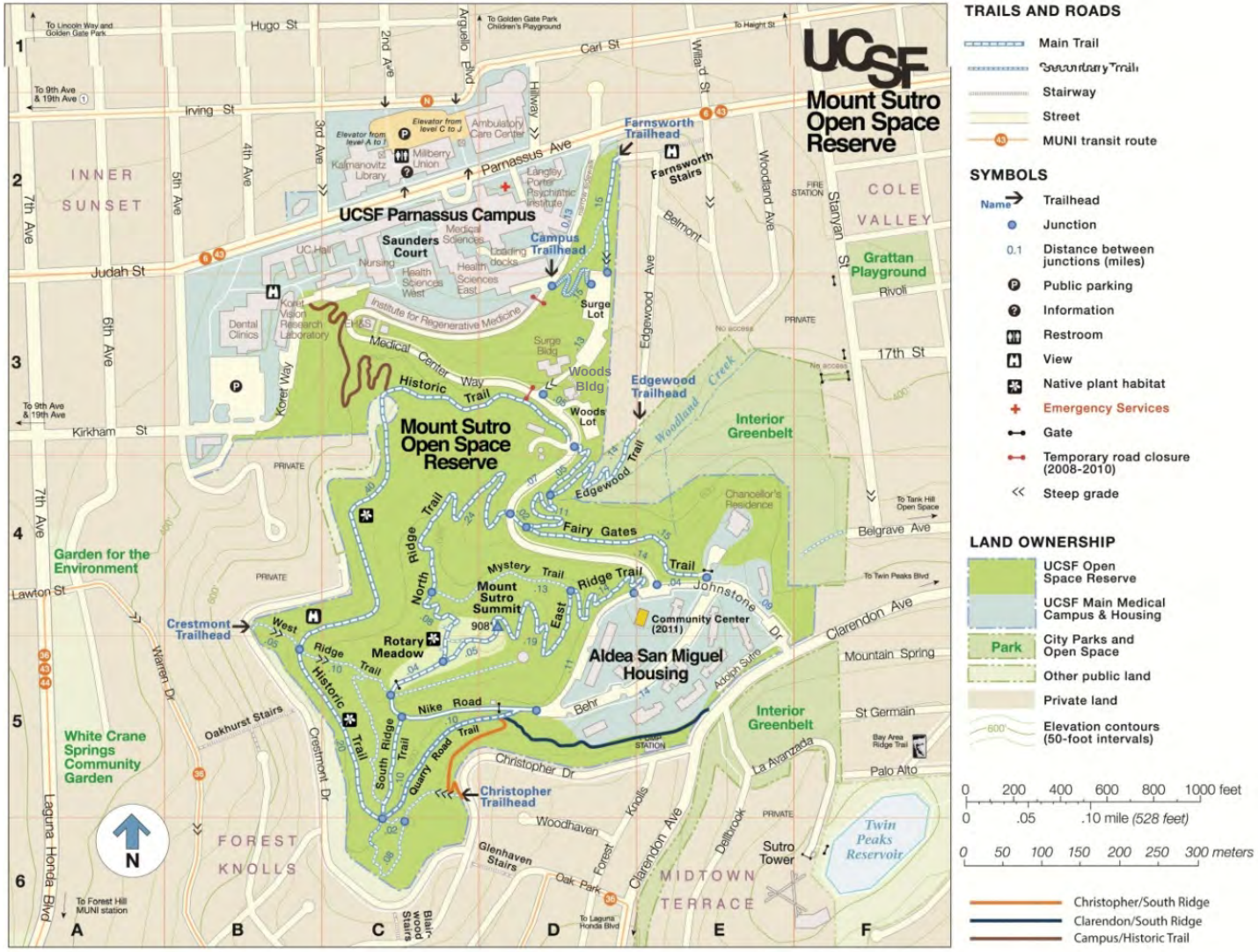
- A narrow trail, identified as the Ishi Loop in the 2001 Management Report[22], branches off the Belgrave Trail to the rock outcrops northeast of the Chancellor's residence.

- The East Boundary Trail connects the Surge Lot and Farnsworth Lane and runs along the Reserve's east boundary. A narrow trail (the Farnsworth Trail) branches off the East Boundary Trail at its midpoint down to Medical Center Way.

The Historic and Fairy Gates trails have constructed alignments. These two trails were laid out to align with the natural terrain. The North, East, West and South Ridge trails, the Mystery Trail, the Edgewood Trail and the Ishi Trail developed from use over time. These paths tend to have steeper alignment up the hillsides and are more prone to erosion and less safe at some locations.

The exact location of any Sutro-constructed paths is not known. It is likely that the present-day Historic and Fairy Gates trail alignments were either built by Sutro, or around 1878 just prior to his acquisition of Rancho San Miguel. The characteristics of these trails show that they were deliberately planned and laid out. These two trails were originally part of one alignment but were severed by the construction of Medical Center Way in the early 1960s. Additionally, this constructed trail system appears to have continued down through the forested Woodland Canyon, now part of the Interior Greenbelt, to a trailhead on Stanyan Street at 17th Street. Sometime after the City purchased this portion of the forest, between the eastern edge of the Reserve and Stanyan Street, residents blocked off the trailhead at Stanyan Street, and this portion

[22] EDAW Inc. *Mount Sutro Open Space Reserve Management Plan*, 2001.




Source: Sutro Stewards and UCSF

**Figure 4.4-5**
Existing and Proposed Trails

of the trail was no longer maintained or used. A group of volunteers known as the Sutro Stewards reconstructed the Interior Greenbelt portion of the trail (now called the Lower Historic Trail) in partnership with the San Francisco Recreation and Park Department. The trail reopened in June 2011, and its western trailhead now connects to the Edgewood Trail just inside the Reserve's boundary.

Based on a review of historical maps and aerial photographs, other paths and unpaved roads were added and subsequently abandoned within the Mount Sutro Cultural Landscape Study Area based on land use and activities on the property. In a 1935 aerial photograph, unpaved paths or roads are clearly visible and continue to be visible in aerial photographs through the late-1950s. By the 1960s, the trees' canopies block views of the ground.

According to the 2001Mount Sutro Open Space Reserve Management Plan, the trails were first informally mapped in the 1970s, and at that time there was a "fairly extensive unimproved dirt trail system" which was maintained by UCSF "for a period of time" until maintenance funding became unavailable. Beginning in 1999, the University renewed the trail maintenance effort on "most of the trails." During the period when UCSF suspended maintenance, a number of the trails became overgrown with poison oak, blackberry and other low-growing plants and were covered with forest debris and in some cases fallen trees to the point that they were not readily apparent and impassable." Around 2005, a group of local volunteers organized themselves into the Sutro Stewards and began an ongoing program of trail restoration activities. The historical research and physical surveys that have been undertaken as part of their work have led to a rediscovery of trails that had fallen out of use and to a broader understanding of the overall trail system. According to Craig Dawson, the Executive Director of the Sutro Stewards, when the group began their work, the four ridge trails, the Mystery Trail, the Fairy Gates Trail, and the Edgewood Trail were visible. The Stewards have undertaken repair and restoration on all of these trails. Some changes were made for safety and erosion control (the upper North Ridge, East Ridge and Edgewood trails) and to provide better links between the trails (a new section of the North Ridge Trail was added at Medical Center Way as a connector to the Fairy Gates and Edgewood trails). Their work in 2005 and 2006 led to the rediscovery and repair of the Historic Trail which was "lost" due to the accumulation of forest debris and eroded soil.

## Vegetation Features

Vegetation features include individual or groups of plants and include indigenous, naturalized, and introduced species.[31]

Within the Reserve boundaries there are three main types of vegetation features: the forest, several small native plant communities, and the Rotary Meadow, a native plant demonstration area at the summit. With the exception of the summit, the Reserve is covered by a dense stand of trees that is dominated (approximately 82 percent) by blue gum eucalyptus. The predominance of eucalyptus reflects the forest's origins from the trees planted by Adolph Sutro in the late 1880s

[31] National Park Service 1996, page 15.

and 1890s as part of the Sutro Forest. While some of the original trees from the Sutro planting remain, the current composition of the forest reflects the regeneration that has occurred over the past 120 years as impacted by logging and fires, and past maintenance practices that resulted in stump sprouting, by the spread of exotic species onto the site, and by the microclimates of the site. The 2001 EDAW Management Plan reported that most trees are less than 12 inches in diameter. It is estimated that there are approximately 45,000 or more trees in the Reserve, but most are very young, small trees. This dense spacing and predominance of small trees continues today. In addition to the eucalyptus, other tree species include Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus macrocarpa*), blackwood acacia (*Acacia melanoxylon*), coast redwood (*Sequoia sempervirens*), plum (*Prunus domestica*), cherry (*Prunus* spp.) and Bailey's acacia (*Acacia baileyana*).[32]

The forest understory is composed mainly of Himalayan blackberry, California blackberry (*Rubus ursinus*), elderberry (*Sambucus spp.*), French broom, snowberry (*Symphoriocarpus albus*), holly (*Ilex spp.*), myoporum (*Myoporum lactum*), toyon (*Heteromeles arbutifolia*), cotoneaster (*Cotoneaster lacteus*), Victorian box (*Pittosporum undulatum*) and currant (*Ribus spp.*). The most common groundcovers include English ivy (*Hedera helix*), poison oak (*Toxicodendron diversilobum*), fern (*Polystichum* spp.) and vetch (*Vicia* spp.). In all, 93 species of plants have been identified on Mount Sutro, with herbaceous perennials that grow low to the ground accounting for the majority of this diversity. The 2001 EDAW Management Plan described the understory as being dominated by the ivy, blackberry, other invasive exotic species and the same conditions exist today. Ivy grows up tree trunks and along with the blackberry completely covers the ground.

There are four areas that contain concentrations of native species. These include (1) an area with a coastal terrace community encircling the area north, east, and west of the Chancellor's residence, (2) a second coastal terrace community at the north edge of the summit clearing, (3) a native plant community consisting of several species of ferns located in the northwest portion of the Reserve on a north-facing embankment along lower Medical Center Way, and (4) small populations of California sagebrush and coyote bush at the summit clearing. Additionally, poison oak, sword fern, and elderberry occur throughout the site. The summit contains a native plant demonstration area planted in 2003 and funded by a grant from the Rotary Club of San Francisco.

The Aldea housing complex includes some mature eucalyptus, coastal redwoods as well as exotic and native plants that were planted as part of the ornamental landscape around this complex. The land around the buildings was excluded from the legal boundary of the Reserve.

The 12-acre portion of the City's Interior Greenbelt is adjacent to the Reserve and has a eucalyptus forest that is indistinguishable from the Reserve since it, too, was part of the original Sutro Forest planting and has experienced similar regeneration conditions. The 2001 EDAW Management Plan noted that the density of the trees in this area is generally higher than in the Reserve. There is a separate stand of trees located south of Clarendon Avenue surrounding the base of Sutro Tower which is within the City's Interior Greenbelt. The construction of Clarendon

[32] EDAW 2001, pgs 20-21.

Avenue in the 1930s divided the forest into these separate areas. The trees in this portion of the Interior Greenbelt south of Clarendon Avenue were in the original Sutro Forest planting.

Until the mid-1950s, the forest on both sides of Clarendon Avenue remained largely intact. In the mid-1950s, the Midtown Terrace neighborhood altered the topography and resulted in the removal of the forest south of Clarendon Avenue. The Forest Knolls development, started in the late 1950s, resulted in the removal of the portion of the forest in the area located between present-day Christopher and Crestmont Drives and Laguna Honda and the north side of Clarendon Avenue. Today the only large stands of trees remaining from the Sutro Forest are located at Mount Davidson and Mount Sutro. The trees at Mount Davidson are owned by the city and are managed by the San Francisco Recreation and Park Department. The trees at Mount Sutro include those within the University-owned Reserve and those on the adjacent, 12-acre, City-owned Interior Greenbelt.

## Small-scale Features

Small-scale features in a cultural landscape may be functional, decorative, or both. Small-scale features in the Reserve are generally associated with the present-day recreational or University-related uses. There are a few isolated remnants of past uses, possibly associated with the Nike site and with the original trails laid out by Sutro.

Examples of small-scale features associated with the present-day recreational use of the Reserve include trail markers, drainage culverts along the trails and a storage area for trail maintenance materials (located at the intersection of the Nike Road and the road to the water tanks just south of the summit). Examples of small-scale features related to UCSF-related uses include signs (i.e., the "San Francisco Rotary Meadow" sign at the summit, traffic and directional signs), light fixtures, bollards and a chain across the entrance to the Nike Road, guardrails along Medical Center Way, and construction debris from the original Affiliated Colleges buildings located along the road to the water tanks just south of the summit. Examples of small-scale features that may be associated with the Nike site include the remnant of a chain link fence just north of the East Ridge Trail and a guard rail along Nike Road.

There are about a half-dozen low, stone drywalls that act as retaining walls to support the outer edges of the Historic Trail where it passes through rock outcrops (i.e., where it would have been difficult to cut the grade and fill with soil). Similar examples of this type of edging or retaining wall were found along the Fairy Gates Trail by the Sutro Stewards during their trail restoration efforts. The Stewards also noted this same type of drywall was found on another trail remnant in the Inner Greenbelt area. These walls are likely associated with the original construction of the trails by Adolph Sutro, since the walls reflect a common construction method of the period. Similarly constructed drystone retaining walls were used to support the edges of parcels on the west side of Stanyan Street, along the original east boundary of the Sutro Forest; this steeply sloped area was subdivided into level lots for residential construction in the mid-1880s.

### Archaeological Features

The sites of prehistoric or historic activities or occupation may be marked by foundations, ruins, changes in vegetation and surface and underground remains. These archaeological features provide valuable information about earlier uses, spatial organization, and features that are no longer intact or no longer evident on the ground's surface.[33] No archaeological resources have been recorded within the Reserve. However two sites within the Reserve are unofficially associated with Ishi, the name given to the lone survivor of the northern California tribe of Yahi Indians, who lived and worked at the Anthropology Museum on the UCSF Parnassus Heights campus between 1911 and 1916. One site is the large rock outcropping which creates an overhang located southeast of the Chancellor's residence. The second is a deep cave with multiple chambers that is located northwest of the Chancellor's residence. In 1998, UCSF retained an archaeologist to perform archaeological testing and excavation in the area, but no artifacts that may have been attributable to Ishi were found.

## 4.4.3 EVALUATION AND FINDINGS

Based on the analysis above, the Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 2 (Persons) for its association with Adolph Sutro and his development of the Sutro Forest. The period of this significance extends from 1886 when Sutro first began to plant the Sutro Forest until his death in 1898. Beginning in 1886, Sutro conceived of and planted an expansive forest across the 1,200-acre tract of land that he purchased in San Francisco's Outside Lands in 1880; this planting included the Mount Sutro area. As part of his development of the cultural landscape Sutro appears to have constructed a trail system throughout the Mount Sutro area. Sutro's vision for the Mount Sutro area was conceived within late nineteenth-century naturalistic landscape design ideals and used this era's large-scale afforestation practices which viewed planting trees as a way to address concerns over a diminishing resource and as a way to improve the land. Other extant examples of late-nineteenth century, large-scale afforestation efforts in San Francisco include the Presidio Forest, trees at Stern Grove and Pine Lake Park, and plantings within Golden Gate Park.

Additionally, since the late nineteenth century, San Franciscans have identified Mount Sutro not only as a geographical feature but as a specific place—a wooded retreat within the city that provides a naturalistic landscape experience and opportunities for recreation. The Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 1 (Events) for its association with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for the city. The period of this significance extends from 1886 to the present.

[33] NPS, *National Register Bulletin 30* (1989), page 6.

## Boundary

As noted previously, the evaluation in the Cultural Landscape Evaluation Report includes the 61-acre Reserve. However, the Mount Sutro Cultural Landscape consists of the 61-acre Reserve that is owned and managed by UCSF and a 12-acre portion of the City-owned Interior Greenbelt that extends from the east side of the Reserve to Stanyan Street. There is no obvious or visual boundary distinction between these two areas. The forests on both properties (the Reserve and this portion of the Interior Greenbelt) were part of the original Sutro Forest planting and are associated with the significance of the Mount Sutro Cultural Landscape under California Register Criteria 1 and 2. However, the Interior Greenbelt is not under UCSF's jurisdiction and no survey was conducted to document existing conditions and to evaluate the integrity of the Interior Greenbelt in relationship to the Mount Sutro Cultural Landscape. A portion of the Interior Greenbelt extends south of Clarendon Avenue and surrounds Sutro Tower. The trees on this portion of the Interior Greenbelt also have their origins in the original Sutro Forest planting, but due to its location south of Clarendon Avenue, this area is no longer experienced as part of the Mount Sutro Cultural Landscape.

## Character-Defining Features

There are three categories of character-defining features within the Mount Sutro Cultural Landscape that convey its historical significance in association with Adolph Sutro and his development of the Sutro Forest between 1886 and his death in 1898 (under Criterion 2 [Persons]) and with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area for the city (under Criterion 1 [Events]).

These categories of character-defining features include the forest (vegetation features), the trails (circulation features) and the topographic characteristics of the site (natural features). The character-defining features related to the forest include the presence of a forest that covers the overwhelming majority of the Reserve and whose dominant species is eucalyptus. The character-defining features related to the trails include the Historic and Fairy Gates trails as part of a consciously laid out trail system and the presence of informal or social trails developed over time that provide connections into Mount Sutro from the surrounding neighborhoods. The character-defining features related to the topographic character include the natural features including the steep terrain, rock outcrops, Stanyan Canyon and the summit.

## Integrity

Integrity is the ability of a property to convey its significance. Integrity is composed of seven components—location, design, materials, workmanship, setting, feeling and association.[34] The forest has been altered throughout the years. The most noticeable changes to the portion of the Mount Sutro Cultural Landscape within the Reserve are the division of the landscape by the Medical Center Way and Johnstone Drive alignment and the construction of the Aldea housing

[34] NPS, *National Register Bulletin 15: How to Apply the National Register Criteria* (2002), page 44.

complex on the south slope (which resulted in changes to the topography, the cutting of trees and the addition of roads and buildings). The construction of these and other University-related features have lessened the integrity of design, materials and workmanship. Forest Knolls, located immediately adjacent to the Reserve and the development south of Clarendon Avenue have removed trees from a portion of the area that was historically associated with the Mount Sutro forest. However, the Mount Sutro Cultural Landscape and the Reserve as a part of the Mount Sutro Cultural Landscape continue to exhibit all seven aspects of integrity as explained below.

**Location**

The location of the Mount Sutro Cultural Landscape—both its topographic prominence and its geographical location in the center of San Francisco—is a key component of its identity as a place. From this perspective, the location of Mount Sutro is unchanged and the Reserve retains its integrity of location as a part of the Mount Sutro Cultural Landscape.

**Design**

A property's design reflects historic functions as well as aesthetics. Design elements include the organization of space, proportion, scale, technology, ornamentation and materials. The design of the Mount Sutro landscape is a composition of both natural and cultural elements. There are four general types of cultural landscapes: historic sites, historic designed landscapes, historic vernacular landscapes and ethnographic landscapes.[35]

These types are not mutually exclusive and the present-day Mount Sutro Cultural Landscape has characteristics of both a historic designed landscape and a vernacular one. A historic designed landscape is one that was consciously designed or laid out by a landscape architect, master gardener, architect, engineer or horticulturist according to design principles. The landscape may be associated with a significant person, trend or event in landscape architecture or may illustrate an important development in the theory and practice of landscape architecture. Aesthetic values tend to play a significant role in designed landscapes.

In a historic vernacular landscape, the evaluation of integrity is closely tied to land use and how the form, plan, and spatial organization of a property result from conscious and unconscious decisions over time about where areas of land use, roadways, buildings and structures, and vegetation are located in relationship to natural features and to each other.[36] A historic vernacular landscape evolves through use by the people whose activities or occupancy shaped it, and as a result function plays a significant role in vernacular landscapes.[37]

As noted above, the Mount Sutro Cultural Landscape resulted from the conscious intent of Adolph Sutro to plant a large-scale forest throughout his 1,200-acre Rancho San Miguel. However, unlike Golden Gate Park and the Presidio Forest—two designed landscapes founded on the establishment of a large-scale forest during the same period—there does not appear to be a

[35] NPS 1996, page 4.
[36] NPS 2002, page 44 and NPS 1999, page 22.
[37] NPS 1996, page 5.

written or graphic plan for the Sutro Forest or for Mount Sutro as a specific location within the forest. There were also no definitive written or graphic account of Sutro's ultimate plan or of his intensions for the new landscape he created.

For the first 12 years of its existence, the development of the Sutro Forest (and Mount Sutro as a specific area within the larger forest) was directed by Sutro. However, Sutro's vision for Sutro Forest and for Mount Sutro, in particular, died with him. After his death in 1898, the 20-year battle within his family over the control of his estate, combined with the lack of funds to properly maintain his properties, limited his daughter's ability to maintain Sutro's vision for the Sutro Forest. As a result, the Mount Sutro Cultural Landscape, as a part of this larger Sutro Forest, began to evolve more organically than had been the case during Sutro's lifetime. After his death, the varied activities that occurred at Mount Sutro became the prime factors in shaping this cultural landscape, and it now exhibits the characteristics of a vernacular landscape.

Mount Sutro has generally been perceived and treated as a "natural area" and not as a designed landscape. The cultural landscape's evolution was a byproduct of the regeneration of the forest and activities that occurred within its boundaries. The site's natural topography, Sutro's initial planting of the eucalyptus forest, and his construction of a trail system established the foundation of this landscape. Subsequent activities and land uses—logging, fires, the Nike missile program, the residential development along the west and south sides, UCSF-related development, the ongoing public recreational use, the general lack of maintenance of the forest in the past and the social trails development have all contributed to its current vernacular character.

Mount Sutro's historic designed landscape characteristics reflect its association with the late-nineteenth century forest planted by Adolph Sutro. The Mount Sutro portion of the Sutro Forest represents a small portion of the once expansive Sutro Forest which was originally within the 1,200 acre tract of land. The loss of the overwhelming majority of the Sutro Forest has resulted in the loss of the integrity of design for the Sutro Forest (of which Mount Sutro is a part) in relationship to a historic design associated with Adolph Sutro. The integrity of design for the Mount Sutro Cultural Landscape area as a component of the Sutro Forest has also been impacted by the changes to the forest character as described below under "Materials and Workmanship."

However, Mount Sutro's vernacular landscape character (or design) has evolved because of an overlay of activities and influences- the original development of the site by Adolph Sutro (planting the forest and laying out trails), the landscape's evolution into a naturalistic landscape within San Francisco's urban environment and the landscape's informal recreation use. The presence of a forest that is predominantly eucalyptus (its primary vegetation feature), the presence of a consciously laid out trail system (its primary circulation feature), the presence of informal or social trails which have developed over time to provide connections into Mount Sutro from the surrounding neighborhoods, and the natural topographic characteristics of the site are features that have been consistently associated with its vernacular landscape character (or design) since the late 1880s. All of these vernacular landscape characteristics remain today. In summary, the integrity of design for the portion of the Mount Sutro Cultural Landscape located within the Reserve remains in relationship to its vernacular landscape character.

**Materials and Workmanship**

As noted in National Register Bulletin 15, materials are the physical elements that were combined during a particular period of time and in a particular pattern or configuration to form a historic property. Workmanship is strongly linked to materials and provides evidence of the technology or aesthetic principles of a historic period, and reveals individual, local, regional, or national applications of both technological practices and aesthetic principles.[38] The key materials and associated workmanship for the Mount Sutro Cultural Landscape are those associated with its character-defining features—the forest, the trail system, natural topographic characteristics and recreational land use.

Materials and workmanship for the forest are reflected in the species, composition, and location and arrangement of the trees. The forest looks markedly different than it did during Sutro's lifetime. The materials and workmanship for the portion of the Sutro Forest located within the Reserve has been altered by the regeneration process over the past 120 years. With the exception of the summit, the Reserve continues to be covered by a dense stand of trees that is dominated by blue gum eucalyptus. The forest and the predominance of the eucalyptus reflect the forest's origins by Adolph Sutro in the late 1880s and 1890s as part of the Sutro Forest.

Materials and workmanship for the designed trails (the Historic and Fairy Gates trails) are reflected in the grading and drystone retaining walls that modify the natural topography to create narrow dirt-paved paths. Although these trails have been rehabilitated and in some places reconstructed by the recent efforts by the Sutro Stewards, the evidence of the historic use of materials and workmanship remains intact. To the extent possible given the addition of Medical Center Way, the Sutro Stewards followed the original alignment for the repairs and rebuilt the drystone walls using the original types of materials and construction techniques.

The materials and workmanship of the natural topographic characteristics of the Mount Sutro Cultural Landscape include the steep grades and rock outcroppings—both of which remain.

In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of materials and workmanship.

**Setting**

Setting is the physical environment of a historic property and refers to the character of the place or location in which the property played its historical role. The National Register Bulletin 15 directs that setting should be examined both within the exact boundaries of the property and between the property and its surroundings.[39]

During Adolph Sutro's lifetime, the setting within the Mount Sutro Cultural Landscape was of a large, contiguous forest that was part of the much larger Sutro Forest. During the first half of the

[38] NPS 2002, p. 45.
[39] Ibid.

20th century the total area of the Sutro Forest was dramatically reduced due to the city's development within its boundaries. However, the internal setting of the portion of the Mount Sutro Cultural Landscape located within the 61-acre Reserve continues to be dominated by a contiguous forest. UCSF's development within the Reserve (i.e., the Aldea housing complex, the Woods and Surge buildings and their respective parking lots, roads, etc.) has lessened the integrity of setting in the immediately adjacent areas, but outside of the direct sightlines of the UCSF features, the integrity of the setting remains.

Mount Sutro Cultural Landscape's setting in relationship to the San Francisco landscape—is based on the contrast between the two. Initially, this contrast was between the dense, green expanse of forest that covered the peak, and the sparsely developed city landscape. Today, this contrast in setting is more pronounced with the dense urban development that surrounds it, resulting in a visual boundary that defines Mount Sutro (including the City's Interior Greenbelt to the east). In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of setting.

**Feeling**

Feeling is a property's expression of the aesthetic or historic sense of a particular period of time.[40] The feelings associated with the Mount Sutro Cultural Landscape include those generally associated with its forested areas. Mount Sutro continues to exhibit this integrity of feeling, and as was the case with the integrity of setting, the feelings associated with the Mount Sutro Cultural Landscape are intensified by the contrast with San Francisco's highly urbanized environment that surrounds it. In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of feeling.

**Association**

Association includes the events and historic contexts that shape the development of the Mount Sutro Cultural Landscape during its period of significance (1886-1898 for its association with Adolph Sutro [under Criterion 2] and 1886-present for its association with recreational development within naturalistic landscapes in San Francisco [under Criterion 1]). While Mount Sutro developed as the result of a number of historical events or within a number of historic contexts, its key associations are with Adolph Sutro and his development of the Sutro Forest and with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area for the city. These two key associations remain, as evidenced by the name "Mount Sutro" and its largely synonymous identification with the Sutro Forest, by the designation of the area as the "Mount Sutro Open Space Reserve" by the University of California Regents, and by the continuing use of the landscape as a public recreational area. In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of association.

[40] Ibid.

### Summary of Significance of the Reserve

Based on the above evaluation, the Reserve is a historical resource for the purposes of CEQA and is eligible for inclusion on the California Register of Historical Resources. The Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 2 (Person) for its association with Adolph Sutro and his development of the Sutro Forest; the period of this significance extends from 1886 when Sutro first began to plant the Sutro Forest to his death in 1898. Additionally, the Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 1 (Events) for its association with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for the city; the period of this significance extends from 1886 when Sutro first began to plant the forest to the present. The Reserve maintains its integrity related to these two areas of significance.

The character-defining features that convey its historical significance include (1) the presence of a forest that covers the overwhelming majority of the land area and whose dominant species is eucalyptus, (2) the presence of the Historic and Fairy Gates trails as part of a consciously laid out trail system and the presence of informal or social trails which have developed over time related to land use activities and to provide connections into Mount Sutro from the surrounding neighborhoods, and (3) the natural topographic characteristics of the site including the steep terrain, the rock outcrops, Stanyan Canyon, and the summit.

## 4.4.4 REGULATORY CONSIDERATIONS

### State

Under CEQA, public agencies must consider the effects of their actions on both "historical resources" and "unique archaeological resources." Pursuant to Public Resources Code (PRC), Section 21084.1, a "project that may cause a substantial adverse change in the significance of an historical resource is a project that may have a significant effect on the environment."

"Historical resource" is defined by statute (see PRC, Section 21084.1 and CEQA Guidelines section 15064.5 (a) and (b)). The term covers any resource listed in or determined to be eligible for listing in the California Register. The California Register includes resources listed in or formally determined eligible for listing in the National Register, as well as some California State Landmarks and Points of Historical Interest.

Properties of local significance that have been designated under a local preservation ordinance (local landmarks or landmark districts) or that have been identified in a local historical resources inventory may be eligible for listing in the California Register and are presumed to be "historical resources" for the purposes of CEQA unless a preponderance of evidence indicates otherwise (PRC, Section 5024.1; California Code of Regulations, Title 14, section 4850). Unless a resource listed in a survey has been demolished, lost substantial integrity, or there is a preponderance of

evidence indicating that it is otherwise not eligible for listing, a lead agency should consider the resource to be potentially eligible for the California Register.

In addition to assessing whether historical resources potentially impacted by a proposed project are listed or have been identified in a survey process, lead agencies have a responsibility to evaluate them against the California Register criteria prior to making a finding as to a proposed project's impacts on historical resources (PRC, Section 21084.1; CEQA Guidelines, section 15064.5(a)(3)). In general, a historical resource, under this approach, is defined as any object, building, structure, site, area, place, record, or manuscript that:

a) Is historically or archaeologically significant; or is significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political or cultural annals of California; and,

b) Meets any of the following criteria:

1. Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage;

2. Is associated with the lives of persons important in our past;

3. Embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of an important creative individual, or possesses high artistic values; or,

4. Has yielded, or may be likely to yield, information important in prehistory or history.[41]

Potential eligibility for the California Register also rests upon the integrity of the resource. Integrity is defined as the retention of the resource's physical identity that existed during its period of significance. Integrity is determined through consideration of the setting, design, workmanship, materials, location, feeling and association of the resource.

CEQA also requires lead agencies to consider whether projects would impact "unique archaeological resources." PRC, Section 21083.2(g) defines "unique archaeological resource" as an archaeological artifact, object, or site about which it can be clearly demonstrated that, without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

1. Contains information needed to answer important scientific research questions and that there is a demonstrable public interest in that information.

2. Has a special and particular quality such as being the oldest of its type or the best available example of its type.

[41] CEQA Guidelines, Section 15064.5 (a)(3)

3. Is directly associated with a scientifically recognized important prehistoric or historic event or person.

Treatment options under PRC, Section 21083.2 include activities that preserve such resources in place in an undisturbed state. Other acceptable methods of mitigation under PRC, Section 21083.2 include excavation and curation or study in place without excavation and curation (if the study finds that the artifacts would not meet one or more of the criteria for defining a "unique archaeological resource").

Other state requirements for cultural resources management appear in the PRC Chapter 1.7, Section 5097.5 "Archaeological, Paleontological, and Historical Sites," and Chapter 1.75 beginning at Section 5097.9 "Native American Historical, Cultural, and Sacred Sites" for lands owned by the state or a state agency.

The disposition of Native American burials is governed by Section 7050.5 of the California Health and Safety Code and PRC, Sections 5097.94 and 5097.98, and fall within the jurisdiction of the Native American Heritage Commission (NAHC).

## 4.4.5 SIGNIFICANCE STANDARDS AND METHODOLOGY

### Significance Criteria

According to the Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment if it would:

- Cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5;
- Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5;
- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature; or
- Disturb any human remains, including those interred outside of formal cemeteries.

### Issues Not Discussed Further

The NOP/Initial Study for the proposed project determined that the EIR will assess the Mount Sutro Open Space Reserve to determine whether it qualifies as a historical resource and whether effects of the proposed project on historical resources will be significant. Accordingly, these topics are analyzed in this chapter.

As discussed in the NOP/Initial Study for the proposed project, the site contains no known archeological resources. However, as discussed on page 4.4-25 of this chapter, Ishi, the lone

survivor of the northern California tribe of Yahi Indians, lived and worked at the Anthropology Museum on the UCSF Parnassus Heights campus site between 1911 and 1916. He also frequented Mount Sutro, where he demonstrated his skills on arrow-making and other aspects of his culture. Because the possibility of encountering archaeological resources while implementing management activities cannot be ruled out, the Initial Study for the proposed project identified a mitigation measure (shown below) from the LRDP Amendment #2 EIR that required work stoppage and investigation into the find in the event of an accidental discovery of archaeological resources. The Initial Study determined that with the implementation of the mitigation measure, impacts on archaeological resources would be reduced to less than significant levels. Therefore, archaeological resources are not analyzed further in the EIR.

> **Mitigation Measure #1: Archaeological Resources***:* Grading and soil disturbance associated with the proposed project could cause substantial adverse changes to archaeological resources at the project site. Should an archaeological artifact be discovered at the site during ground disturbance activities, pursuant to CEQA Guidelines 15064.5(f), "provisions for historical or unique archaeological resources accidentally discovered during construction" should be instituted. In the event that any prehistoric or historic subsurface cultural resources are discovered during ground disturbing activities, all work within 100 feet of the resources shall be halted and UCSF shall consult a qualified archaeologist/paleontologist to assess the significance of the find (per Public Resources Code Section 5024.1, Title 14 California Code of Regulations, Section 4852 and/or Public Resources Code 21083.2 in the event of a unique archaeological find). If any find is determined to be significant and will be adversely affected by the project, representatives of UCSF and the qualified archaeologist/paleontologist would meet to determine the appropriate avoidance measures or other appropriate mitigation (per CEQA Guidelines 15064.5(b) and Public Resources Code 21083.2). All significant cultural materials recovered shall be subject to scientific analysis, professional museum curation, and documented by the qualified professional according to current professional standards (per the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44716)). If the discovery includes human remains, CEQA Guidelines 15064.5 (e)(1) shall be followed. In the event of the accidental discovery or recognition of any human remains in any location other than a dedicated cemetery, steps to be taken include:
>
> (1) There shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until:
>
> > (A) The coroner of the county in which the remains are discovered must be contacted to determine that no investigation of the cause of death is required, and
> >
> > (B) If the coroner determines the remains to be Native American: i) The coroner shall contact the Native American Heritage Commission within 24 hours. ii) The Native American Heritage Commission shall identify the person or persons it

believes to be the most likely descended from the deceased Native American.
iii) The most likely descendent may make recommendations to the landowner or the person responsible for the excavation work, for means of treating or disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in Public Resources Code Section 5097.98, or

(2) Where the following conditions occur, the landowner or his authorized representative shall rebury the Native American human remains and associated grave goods with appropriate dignity on the property in a location not subject to further subsurface disturbance.

(A) The Native American Heritage Commission is unable to identify a most likely descendent or the most likely descendent failed to make a recommendation within 24 hours after being notified by the commission.

(B) The descendant identified fails to make a recommendation; or

(C) The landowner or his authorized representative rejects the recommendation of the descendant, and the mediation by the Native American Heritage Commission fails to provide measures acceptable to the landowner.

There are no known paleontological resources on Mount Sutro. However, there are rock outcroppings atop the hill that add to its unique character. Because no removal or alteration of these rock outcroppings are proposed, the NOP/Initial Study for the proposed project found that implementation of the proposed project would not have a substantial adverse effect on paleontological resources or unique geologic features. Additionally, the project site was not historically used as a cemetery or interment location, therefore, the NOP/Initial Study for the proposed project concluded that the proposed project would have no impact on human remains and these topics are not further analyzed in the EIR.

## Approach to Analysis

The analysis considers direct and indirect impacts on historical resources. Potential impacts on historic resources are assessed by determining whether the proposed project activities would affect any such resources that have been identified as historical resources for the purposed of CEQA. Once a resource has been identified as significant, it must be determined whether the project would "cause a substantial adverse change in the significance" of the resource (CEQA Guidelines 15064.5(b)). A substantial adverse change in the significance of a resource means "physical demolition, destruction, relocation or alteration of the resource or its immediate surroundings such that the significance of the historical resource would be materially impaired" (CEQA Guidelines Section 15064.5(b)(a). The significance of an historical resource would be materially impaired through the demolition or alteration of the resource's physical characteristics that convey its historical significant and that justify its inclusion in, or eligibility for inclusion in, the California Register (CEQA Guidelines section 15064.5(b)(1) and (2).

Most historical resources are significant because of their association with important events, people or design. As discussed in section 4.4.3 Evaluation and Findings, the Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 2 (Person) and California Register Criterion 1 (Events).

*The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes* (Guidelines for the Treatment of Cultural Landscapes) provides guidance about the appropriate rehabilitation of historic landscape features, such as spatial organization, topography, vegetation, buildings and structures and circulation. As such, the Guidelines for the Treatment of Cultural Landscapes were used to evaluate the proposed changes to the Mount Sutro landscape features. The Guidelines for the Treatment of Cultural Landscapes are not to be construed as CEQA significance criteria. Although compliance with the Secretary of the Interior's Standards for the Treatment of Historic Properties (Secretary's Standards) may indicate that a project would have a less-than-significant impact on a historical resource, a project that does not comply with the Standards does not, by definition, result in a significant impact under CEQA. Alterations that are not consistent with the Secretary's Standards may or may not result in a significant impact under the "material impairment" significance standard of CEQA Guidelines Section 15064.5(b)(1).

## 4.4.6 IMPACTS AND MITIGATION MEASURES

**Impact CULT-1: The project could cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5. (Less than Significant)**

The impact analysis is organized by each element of the project- the four demonstration areas and the "hand-off" area, continued implementation, trail system improvements and ongoing maintenance- followed by a discussion of how each element would impact the character defining features of the historical resources and the potential for "material impairment" of these character-defining features as defined by CEQA.

***Demonstration Areas and the "Hands-off" Management Area***

The proposed management activities and the detailed description of the four demonstration projects (South Ridge Area, Edgewood Avenue Area, North Side of Summit and East Bowl Corridor) and the "Hands-Off" Management Area in the South Ridge Area are discussed in Chapter 3, Project Description.

The proposed Management Plan activities related to the four demonstration areas and the "Hands-off" area were reviewed for their potential to materially impair the character-defining features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the four demonstration areas and the "Hands-off" area activities would demolish or materially alter in an adverse manner the physical characteristics—the character defining features consisting of a forest whose predominant species is eucalyptus, the trail system

and the natural topographic characteristics—of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources.

The evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the activities would be limited to the four demonstration areas; (2) the demonstration areas are located within different parts of the Reserve so that the activities would not be concentrated in any one zone or part of the Reserve; (3) the total area within the demonstration areas would affect only about 7.5 acres of the total 61 acres of land within the Reserve, (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape, and (5) the Reserve would continue to exhibit its seven components of integrity (location, design, materials, workmanship, setting, feeling, and association) as described in Section 4.4.3 Evaluation and Findings. In summary, the proposed activities related to the four demonstration areas and "Hands-off" management area would have a less-than-significant impact on the Reserve as a historical resource.

**Mitigation:** None required

***Continued Implementation***

After the completion and assessment of Demonstration Project 2: Edgewood Avenue Area, management actions in Demonstration Project 2 would be selected for application to the remainder of the Edgewood Avenue Area (shown on Figure 3-4 as area "I" and including lands west of area "I' to Medical Center Way), including the planting of native trees, shrubs and other plants as understory within the existing forest whose predominant species is eucalyptus.

In addition, after the completion and assessment of the Demonstration Project 1: South Ridge Area, management actions proposed in Demonstration Project 1 would be selected for application to other areas of the Reserve, excluding the other demonstration project areas, and the Rotary Meadow at the summit. These management actions would include the planting of native species and enhancement of existing remnant native plant communities.

Of the Reserve's 61 acres, conversion planting would occur in the East Bowl Corridor (about 2 acres) and potentially in Area "K" (about 1.5 acres). Accounting for the loss of eucalyptus-forested area due to these proposed conversion plantings and the conversion of the summit (about 1.5 acres) that has already occurred, about 56 acres of forested area would remain where the predominant species is eucalyptus. Thus, the overwhelming majority of the Reserve would remain a eucalyptus forest, although at a lower density of trees per acre than exists today.

The activities related to the continued implementation of the proposed Management Plan were reviewed for their potential to materially impair the character-defining features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the full implementation of these activities (i.e., the implementation of the Demonstration Project 2 management actions throughout the Edgewood Area, the implementation of the Demonstration Project 1 management actions throughout other areas of the Reserve [excluding the other

demonstration project areas and the Rotary Meadow at the summit], and the planting of native species and enhancement of existing remnant native plant communities) would demolish or materially alter in an adverse manner the physical characteristics—the character defining features consisting of a forest whose predominant species is eucalyptus, the trail system and the natural topographic characteristics—of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources.

The evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the proposed vegetation management actions described in Section 3.5.2.: Continued Implementation, (2) the best management practices described in Section 3.5.5: Best Management Practices, (3) 56 acres of forested area where the predominant species is eucalyptus would remain, (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape, and (5) the Reserve would continue to exhibit its seven components of integrity (location, design, materials, workmanship, setting, feeling, and association) as described in Section 4.4.3: Evaluation and Findings. In summary, the proposed activities related to the continued implementation of the proposed Management Plan would have a less-than-significant impact on the Reserve as a historical resource.

**Mitigation:** None required.

***Trail System Improvements***

The proposed Management Plan activities related to the trail system improvements, including the addition of three new trails and new switchbacks, were reviewed for their potential to materially impair the character-defining features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the trail system improvements would demolish or materially alter in an adverse manner the physical characteristics of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources—the character-defining features consisting of a forest whose predominant species is eucalyptus, the trail system, and the natural topographic characteristics.

The evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the trail system improvements would result in minimal vegetation removal; (2) the grading proposed would be limited to minor alterations in the topography in the vicinity of the trail improvements; (3) the existing trails and the three new proposed trails would remain unpaved and (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape. In summary, the proposed activities related to the trail system improvements would have a less-than-significant impact on the Reserve as a historical resource.

**Mitigation:** None required

***Ongoing Maintenance***

UCSF, with the assistance of the Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees and restoring trails. The goals and general description for ongoing maintenance are consistent with the protection of the Reserve as a historical resource. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

**Mitigation:** None required

**Cumulative Impacts**

**Impact CULT-2: The proposed project, in combination with other planned and foreseeable future projects, could result in a cumulatively considerable significant impact related to cultural resources. (Less than Significant)**

The cumulative impact analysis encompasses the entire extant of the Mount Sutro Cultural Landscape including both the 61-acre Reserve and the 12-acre portion of the Interior Greenbelt east of the Reserve extending to Stanyan Street. The cumulative analysis considers whether the incremental contribution of the proposed project, in combination with other past, present and reasonably foreseeable projects, would have a cumulatively considerable impact to the Mount Sutro Cultural Landscape.

In addition to the proposed project, future cumulative projects that have the potential to affect the historical significance of the Mount Sutro Cultural Landscape include the City's management strategies for the Interior Greenbelt as defined in the *Significant Natural Resource Areas Management Plan* ("SNRAMP").[42] The SNRAMP activities proposed in the Interior Greenbelt would focus on (1) improving public access on designated trails, (2) restoring the creek riparian corridor, (3) creating a more structurally diverse urban forest habitat for wildlife, and (4) creating increased and more sustainable populations of sensitive plant species. The SNRAMP stated that "[i]mplementation of the management recommendations at the Interior Greenbelt would not change significantly the overall look of the park."[43]

Specific vegetation management activities that would occur in the project vicinity under the SNRAMP would include managing herbaceous invasive plants such as Himalayan blackberry, Cape ivy, and Algerian ivy (Recommendation IG-1a), removing approximately 140 eucalyptus trees to enhance seasonal creek and sensitive species habitats (Recommendation IG-1b),[44]

---

[42] EIP Associates, *Significant Natural Resource Areas Management Plan, Final Draft* (San Francisco Recreation and Park Department, 2006).

[43] Ibid., page 6.23-3.

[44] Approximately 100 "small and medium-sized" eucalyptus trees would be removed from a one-acre area (designated as "MA-2a") along the eastern boundary of the 12-acre northern parcel near Stanyan Street as part of creek enhancement; the SNRA Management Plan estimated that this represented 28 percent of the trees in this one-acre area. Additionally, approximately 40 eucalyptus trees would be removed from a 0.3-acre area (designed as "MA-2c") in the western tip of this same parcel along its boundary with the Reserve (Recommendation IG-1b); the SNRA Management Plan estimated that this represented 45 percent of the trees in this 0.3-acre area (EIP Associates 2006, page 6.23-4 and Table F-1).

revegetation using native plants to maintain and enhance the existing scrub mosaic communities (Recommendation IG-1c), augmenting existing populations of sensitive plants (Recommendation IG-1d), and considering reintroduction of specific rare plant species (Recommendation IG-1e). Eucalyptus trees would be removed from 1.3 acres of the 12-acre area in the Interior Greenbelt parcel that adjoins the Reserve to the east. The SNRAMP stated that in the short term "the surrounding neighborhood and visitors may notice a decrease in tree density after thinning is complete, but the overall view will not be substantially altered."[45] In the long term "[t]hese areas will be converted to coastal scrub or creek riparian habitats. Once the vegetation is established, the area will appear forested and natural with no evidence of tree removal or disturbance."[46] Trees throughout the remaining 10.7 acres would be managed as an urban forest following general urban management practices to promote the health and diversity of the forest and wildlife habitat (as outlined in General Recommendations GR-15).[47]

Under the SNRAMP, the City plans to develop a new trail linking existing secondary trails with trails on the Reserve (Recommendation IG-2a). Additionally the City would formalize existing social trails that would remain to minimize erosion and to protect creek habitat (Recommendation IG-2b). In June 2011, the City reopened the Lower Historic Trail. The eastern trailhead for this reconstructed trail is located on Stanyan Street at 17th Street and the western end connects to the Edgewood Trail just inside the Reserve.

The proposed project, in combination with the City's management strategies for the Interior Greenbelt as defined in the SNRAMP would not result in an alteration to the historic character of the Mount Sutro Cultural Landscape and would not result in a material impairment of its historical significance in association with Adolph Sutro and his development of the Sutro Forest (California Register Criterion 2 [Persons]) or with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for San Francisco (California Register Criterion 1 [Events]).

The proposed project is intended to provide a benefit by maintaining, improving and restoring the Reserve and would not contribute to long-term, adverse cumulative impacts on the Reserve as a historical resource. No other UCSF or City projects are currently proposed in a sufficiently close proximity such that cumulative impacts related to historical resources would be anticipated. Therefore, the proposed project would not contribute to cumulative adverse impacts related to historic resources.

**Mitigation:** None required.

[45] Ibid., F-10.
[46] Ibid., F-11.
[47] Ibid., page 6.23-4 to 5, Figure 6.23-5, and Table F-1.

## 4.4.7 REFERENCES

Denise Bradley, ASLA and Knapp & VerPlanck Preservation Architects, *Final Mount Sutro Open Space Reserve Cultural Landscape Evaluation Report*, October 3, 2011; revised January 10, 2013.

EDAW Inc., *Mount Sutro Open Space Reserve Management Plan*. Prepared for the University of California, San Francisco, September 2001

United States Department of the Interior, National Park Service (NPS)

*National Register Bulletin 18: How to Evaluate and Nominate Designed Historic Landscapes.* Prepared by J. Timothy Keller and Genevieve P. Keller. http://www.cr.nps.gov/nr/publications/bulletins/nrb18/ (accessed 10 February 2011).

*The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes*. Edited by Charles A. Birnbaum with Christine Capella Peters. Washington, D.C. 1996; http://www2.cr.nps.gov/tps/standards/four-treatments/landscape-guidelines/index.htm (accessed 11 December 2012).

*A Guide to Cultural Landscape Reports: Contents, Process, and Techniques*. Prepared by Robert R. Page, Cathy A. Gilbert, and Susan A. Dolan. Washington, D.C., 1998.

*National Register Bulletin 30: How to Evaluate and Document Rural Historic Landscape*s. Prepared in 1989 by Linda Flint McClelland, J. Timothy Keller, ASLA, Genevieve P. Keller, and Robert Z. Melnick, ASLA. Washington, D.C. http://www.cr.nps.gov/nr/publications/bulletins/nrb30/ (accessed 30 January 2011)

*National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*. Prepared by the staff of the National Register of Historic Places, finalized by Patrick W. Andrus, edited by Rebecca H. Shrimpton, 1990, Revised 1991, 1995, 1997, Revised for Internet 1995, 2001, 2002. Washington, D. C. http://www.nps.gov/history/nr/publications/bulletins/nrb15/ (accessed 30 January 2011)

# 4.5 GEOLOGY AND SOILS

## 4.5.1 INTRODUCTION

This section discusses the local geology in the project vicinity, the regulatory framework for evaluating the geological setting, and analyzes the potential for the proposed project to create geological hazards. The impacts associated with the proposed project are compared with the thresholds of significance adopted pursuant to CEQA.

UCSF has completed various site-specific geotechnical investigations at Parnassus Heights. The studies most recent and relevant to the Reserve were prepared by the firm of Rutherford and Chekene Consulting Engineers in 2006 and 2013.[1] The analysis in this section is based primarily on those studies. Additionally, the U.S. Geologic Survey (USGS) has updated earthquake probabilities and seismic hazard maps, and the California Geologic Survey (CGS) has updated guidance in CGS Special Publication 117A, *Guidelines for Evaluating and Mitigating Seismic Hazards in California,* which were considered in this analysis.

Comments related to geology received during the Initial Study/EIR scoping process included concerns about the following:

- Soil Stability/Landslides – removing vegetation could impact erosion and soil stability, resulting in potential landslides

## 4.5.2 ENVIRONMENTAL SETTING

### Geological Setting

San Francisco is located at the northern tip of the San Francisco Peninsula, within the Coast Ranges geologic province. The Coast Ranges is a northwest-trending series of mountain ranges and valleys. The general geologic setting of the city is characterized by broad valleys underlain by unconsolidated deposits bounded by bedrock hills . The bedrock consists of consolidated rocks of the Franciscan Complex and the Great Valley Sequence of late Jurassic and Cretaceous age (Schlocker, 1974, Blake, et al 2000). The Franciscan Complex generally consists of graywacke (sandstone), shale, chert, greenstone, and melange; in certain places, serpentine, an asbestos-containing rock-type, is found within the shale matrix. The Great Valley Sequence generally consists of sandstone and shale. Bedrock outcrops in hilly areas account for approximately 24 percent of the land surface in San Francisco.

The Reserve portion of the Parnassus Heights site is located at elevations of 375 to 925 feet above mean sea level. Slopes with gradients ranging from 25 to 45 percent characterize the site. Over

[1] Rutherford & Chekene., *Slope Stability Risk Assessment*, August 25, 2006.
Rutherford & Chekene , *Geotechnical and Geologic Evaluation UCSF Mount Sutro Management*, January 7, 2013.

60% of the Reserve has slopes in excess of 30%. Bedrock occurs at or very near the ground surface throughout much of the Reserve, but is locally overlain by surficial materials (Colluvium and shallow landslides) within drainages that have developed along mountain flanks. The reserve is underlain by Franciscan Complex bedrock (chert, greenstone and meta-sandstone and shale).

The Reserve's greenstone is generally fractured, weathered and altered to clay minerals, where exposed to weathering, making it prone to landslides. Mount Sutro has experienced several minor shallow landslides in the surficial materials over the past century. Locations and causes of these landslides have been well documented.

Parnassus Heights is within the City of San Francisco's Special Geologic Study Area for potential ground failure hazards and the California Geologic Survey (CGS) Seismic Hazard Zone for landslides. As the proposed project would involve surficial ground disturbance, the EIR analyzes the potential for the proposed project to result in substantial soil erosion and to expose persons or property to landslides.

***Soil Erosion***

Erosion is the wearing away of soil and rock by processes such as mechanical or chemical weathering, mass wasting, and the action of waves, wind, and underground water. Soils containing high amounts of silt or clay can be easily erodible, while sandy soils are less susceptible to erosion. Excessive soil erosion can eventually damage building foundations and roadways.

The Parnassus Heights site is susceptible to erosion when ground cover is disturbed. Soil erosion potential is reduced once the soil is graded and covered with concrete, structures, or by well-established landscaping. The topic of soil erosion is considered for the proposed project site.

***Landslide Hazards***

A landslide is a mass of rock, soil, and debris displaced down-slope by sliding, flowing, or falling. The susceptibility of land (slope) failure is dependent on the slope and geology as well as the amount of precipitation, excavation, or seismic area activities. In San Francisco, a major earthquake could cause movement of active slides or could trigger new slides in the same general areas of previous slides.

This potential for landslides exists at Parnassus Heights, which is located on steep hills underlain by Franciscan Complex rocks, a type of rock that is susceptible to landslides. However, according to a previous geotechnical investigation, the deposits at the Parnassus Heights campus site are from the Merced and Colma Formations, which consist of unconsolidated sand, silt, and clay. These soils have fair to good stability under seismic conditions (URS Corporation, 1974). None of the more than a dozen known Reserve slope failures has been linked to an earthquake. All of the known Reserves landslides have been linked to precipitation and/or excavation. The

topic of landslides caused by precipitation and/or excavation is considered for the proposed project site.

## 4.5.3 REGULATORY CONSIDERATIONS

### Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was developed to protect the public from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and from other hazards caused by earthquakes. This act requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site must be conducted and appropriate mitigation measures incorporated into the project design. The CGS has completed seismic hazard mapping for portions of California most susceptible to liquefaction, ground shaking, and landslides, including San Francisco.

### California Building Code

The California Building Code (CBC) is another name for the body of regulations known as the California Code of Regulations (CCR), Title 24, Part 2, which is a portion of the California Building Standards Code (CBSC). Title 24 is assigned to the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. The standards apply to the development of structures, and are not applicable to the proposed project.

### University of California Policy on Seismic Safety

The most recent version of the Policy on Seismic Safety was enacted by the Regents August 25, 2011.[2] The purpose of the policy is to the maximum extent feasible by present earthquake engineering practice to provide an acceptable level of earthquake safety for students, employees, and the public who occupy University buildings and other facilities, at all locations of University operations and activities. This policy was revised to require that new University construction comply with the current seismic provisions of the CBSC or local seismic requirements, whichever are more stringent, which in most cases is the CBSC. The standards apply to the development of structures, and are not generally applicable to the proposed project.

## 4.5.4 SIGNIFICANCE CRITERIA

### Significance Criteria

According to the Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment if it would:

[2] http://www.ucop.edu/facil/resg/seismic-safety/

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: i) rupture of a known earthquake fault as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map; ii) strong seismic ground shaking; iii) seismic-related ground failure, including liquefaction; iv) landslides

- Result in substantial soil erosion or the loss of topsoil

- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse

- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994) (California Building Code), creating substantial risks to life or property

- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water

- Exceed the applicable LRDP EIR standard of significance by exposing people to structural hazards in an existing building rated Poor, or Very Poor, under the University's seismic performance rating system, or substantial nonstructural hazards

## Issues Not Discussed Further

As discussed in the Initial Study for the proposed project, the San Francisco Bay Area contains both active and potentially active faults and is considered a region of high seismic activity. The nearest known active fault is the San Andreas fault, which near San Francisco trends offshore north of Colma, and continues northwest through the Pacific Ocean approximately six miles due west of the Golden Gate Bridge. Like the entire San Francisco Bay Area, the project site is subject to groundshaking in the event of an earthquake. However, the project site is not within an Alquist-Priolo Special Studies zone. Proposed management activities would not affect exposure of persons to strong seismic ground shaking. Nor would the proposed project expose persons to seismic-related ground failure as it is not within a liquefaction zone. Therefore, impacts with respect to exposure of persons to rupture of a known earthquake fault, seismic groundshaking, and seismic-related ground failure would be less than significant, and are not discussed further in this EIR.

Soils on the site are not subject to lateral spreading, subsidence, liquefaction, or collapse, and proposed project activities would have no effect on these subject areas. The site is not on expansive soil. Therefore, impacts regarding these topics would be less than significant and are not analyzed further in this EIR

Proposed management activities would have no effect on wastewater disposal systems, or on the exposure of persons to seismically Poor or Very Poor buildings. Impacts regarding these topics would be less than significant and are not analyzed further in this EIR.

### Significance Thresholds

For the purposes of this EIR, geotechnical impacts resulting from the proposed project would be considered significant if the proposed project would expose people or structures to substantial risk of loss, injury, or death involving landslides; or, result in substantial soil erosion.

## 4.5.5 IMPACTS AND MITIGATION MEASURES

**Impact GEO-1: Proposed forest thinning and root loss could impact erosion and soil stability, resulting in potential landslides. (Less than Significant)**

Bedrock occurs at or very near the ground surface throughout much of the Reserve. In general, the soils overlaying the bedrock on Mount Sutro are thin, sandy material. The soil complex is mapped as Candlestick fine sandy loam - Kron sandy loam - Buriburi gravelly loam. The constituent soil types of this complex are likely to occupy different areas of the Reserve. The Candlestick fine sandy loams are usually from 20 to 40 inches thick over bedrock, whereas the Buriburi gravelly loam and the Kron sandy loam are usually from 10 to 40 inches thick over bedrock. Many slopes have less than six inches of soil depth and the summit area of the reserve was scraped of most of its soil in the 1960's.

In general, the shallower soils are on steeper slopes of the Reserve. Soils on steeper slopes are more vulnerable to slope failure and surface erosion, especially where exposed when vegetation is removed. As discussed in the Project Description in Section 3.5.3, forested areas on steep slopes that are inaccessible by heavy equipment (about 15 acres) would not be thinned.

The primary conclusion from the geotechnical slope stability evaluation is that surface runoff control is the most important factor in minimizing the potential for slope stability and erosion problems on the Reserve.[3] The proposed project incorporates best management practices (BMPs) that control surface runoff and soil erosion:

- Disturbed soils resulting from treatment activities will be stabilized prior to the rainy season by spreading woodchips or shreds or other mulch materials over the bare ground.
- Straw wattles, silt fencing, straw bales, or similar sediment control measures will be installed on contours along the lower edge of the treatment areas to prevent excess sediment form entering the watershed, if deemed necessary.

The forest is dominated (82%) by blue gum eucalyptus. Trees would be prioritized for removal if they are dead, diseased, structurally deficient, unhealthy or hazardous. The next priority would be removal of trees less than 12 inches in diameter to achieve desired spacing between trees. Most importantly, trees that are removed will be cut flush to the ground and the roots left in place. The soil stabilizing characteristics of a tree stem from its root system. The stabilizing characteristics of the removed tree are retained until the roots decompose. Eucalyptus roots are notoriously hardy;

[3] Rutherford & Chekene., *Slope Stability Risk Assessment*, August 25, 2006.

trees cut back to the stumps regrow readily from the roots. The project description includes measures such as tarping stumps to ensure that the stumps die and do not re- sprout. Absent outside agents such as insect pests (e.g. wood borer, Phoracantha semipunctata) or fungi (e.g. Rhizomorphs of Armillaria luteobubalina), roots from mature eucalyptus trees typically take at least 5 years to decompose even if these sorts of regrowth preventative measures proposed in the management plan are taken.[4]

Eucalyptus roots are also notoriously opportunistic and aggressive, growing roughly 3 feet a year, depending on environmental conditions.[5] Eucalyptus roots of mature trees can sink 60 feet into the soil and spread out to 100 feet laterally. Following forest-thinning activities, the average distance between trees would be about 30 feet. Post- thinning, the roots of adjacent undisturbed eucalyptus trees would spread laterally in the shallow soil, replacing the soil stabilizing characteristics of the decaying root systems of the trees that are removed. Roots of remaining trees would need to spread about 15 feet (about half of the desired 30-foot spacing between trees) to compensate for removed trees. At a growth rate of roughly 3 feet per year, it would take about 5 years for roots to spread out 15 feet, which is about the same amount of time that it would take for roots of removed trees to decompose as indicated above, Given the rate at which new roots systems are expected to replace decaying root systems, and given that tree thinning activities would not occur on steep slopes, impacts on slope stability as result of the proposed project would not be significant.

**Mitigation:** None required.

**Impact GEO-2: Proposed construction of trails could impact erosion and soil stability, resulting in potential landslides. (Potentially Significant, Less than Significant with Mitigation)**

UCSF maintains many existing trails to improve access throughout the Reserve for the enjoyment of visitors. Three new trails are proposed as part of the proposed project: (1) a trail on the north side of the Reserve connecting the Historic Trail to the Parnassus Heights campus site, allowing for ease of access to/from the built environment on the Parnassus Heights campus site; (2) a trail connecting the South Ridge and Quarry Trails to Christopher Drive, allowing for easier public access from the south side of the Reserve; and (3) an extension of this new trail to Clarendon Avenue and to trails to the Interior Greenbelt (on City-owned land) and southeast of the Reserve (see Figure 3-6).

The creation of these new trails will require minimal vegetation removal, minor amounts of grading and new trail markers. Trail construction has the potential to cause erosion and landslides if surface runoff is not properly controlled. All of the trails traverse or are immediately adjacent to areas identified as of being at risk to landslides.

---

[4] http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7460.html
http://www.na.fs.fed.us/pubs/silvics_manual/volume_2/eucalyptus/globulus.htm

[5] The Eucalyptus of California, Robert L. Santos Librarian/Archivist, California State University, Stanislaus
http://wwwlibrary.csustan.edu/bsantos/euctoc.htm#toc

Ground disturbance not associated with trails would be minor with the proposed project. The proposed project incorporates best management practices (BMPs) to address ground disturbance not associated with trails.

- Disturbance to existing grades and vegetation will be limited to the actual treatment or restoration areas and necessary access routes. Placement of all trails, staging areas and other facilities will avoid and limit disturbance to existing native plants to the maximum extent practicable, with the exception of poison oak. Where possible, existing ingress or egress points will be used and contours of the work area will be returned to pre-construction conditions.

The following mitigation measure would ensure that impacts of the project with regard to geology and soils are less than significant.

**Mitigation Measure GEO-1**: To minimize the potential for soil erosion and landslides, the following measures should be included in trail construction planning:

- Prior to the start of construction of new trails, the trail design should be reviewed by an engineer in the context of its potential impact on slope stability and erosion hazards.
- Cut slopes associated with the trails will be located in such a way as to avoid undermining the stability of the toe of existing slopes.
- Surface runoff will be directed towards swales on the upslope side of the trail.
- The trails be reviewed periodically by UCSF staff during the first year following construction and remedial action will be taken to address any evidence of erosion.

**Significance After Mitigation:** Less than significant

## 4.5.6 REFERENCES

Rutherford & Chekene., Slope Stability Risk Assessment, August 25, 2006.

Rutherford & Chekene , Geotechnical and Geologic Evaluation UCSF Mount Sutro Management, January 7, 2013

URS Corporation/John A. Blume and Associates, San Francisco Seismic Safety Investigation, 1974

# 4.6 GREENHOUSE GAS EMISSIONS

This section describes the existing global, national, and statewide conditions for greenhouse gases (GHG) and global climate change and evaluates the potential impacts on global climate change from implementation of the proposed project based upon thresholds of significance under CEQA.

Comments related to greenhouse gas emissions received during the Initial Study/EIR scoping process included concerns about the following:

- Release of greenhouse gas emissions due to tree removals

## 4.6.1 ENVIRONMENTAL SETTING

### Background

Global climate change refers to any significant change in climate measurements, such as temperature, precipitation, or wind, lasting for an extended period (i.e., decades or longer) (U.S. EPA 2008b). Climate change may result from:

- Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun;
- Natural processes within the climate system (e.g., changes in ocean circulation, reduction in sunlight from the addition of GHG and other gases to the atmosphere from volcanic eruptions); and
- Human activities that change the atmosphere's composition (e.g., through burning fossil fuels) and the land surface (e.g., deforestation, reforestation, urbanization, desertification).

The natural process through which heat is retained in the troposphere[1] is called the "greenhouse effect." The greenhouse effect traps heat in the troposphere through a threefold process as follows: (1) short-wave radiation in the form of visible light emitted by the Sun is absorbed by the Earth as heat; (2) long-wave radiation is re-emitted by the Earth; and (3) Certain gases termed greenhouse gases (GHGs) in the upper atmosphere absorb or trap the long-wave radiation and re-emit it back towards the Earth and into space. This third process is the focus of current climate change actions.

While water vapor and carbon dioxide ($CO_2$) are the most abundant GHGs, other trace GHGs have a greater ability to absorb and re-radiate long-wave radiation. To gauge the potency of GHGs, scientists have established a Global Warming Potential (GWP) for each GHG based on its ability to absorb and re-emit long-wave radiation over a specific period. The GWP of a gas is determined using $CO_2$ as the reference gas, which has a GWP of 1 over 100 years (IPCC 1996). For

[1] The troposphere is the bottom layer of the atmosphere, which varies in height from the Earth's surface to 10 to 12 kilometers).

example, a gas with a GWP of 10 is 10 times more potent than $CO_2$ over 100 years. The use of GWP allows GHG emissions to be reported using $CO_2$ as a baseline. The sum of each GHG multiplied by its associated GWP is referred to as "carbon dioxide equivalents" ($CO_2e$). This essentially means that 1 metric ton of a GHG with a GWP of 10 has the same climate change impacts as 10 metric tons of $CO_2$.

## Greenhouse Gases

State law defines GHGs to include the following six compounds:

- **Carbon Dioxide ($CO_2$).** Carbon dioxide primarily is generated by fossil fuel combustion from stationary and mobile sources. Due to the emergence of industrial facilities and mobile sources over the past 250 years, the concentration of carbon dioxide in the atmosphere has increased 35 percent. (U.S. EPA 2008c). Carbon dioxide is the most widely emitted GHG and is the reference gas (GWP of 1) for determining the GWP of other GHGs. In 2004, 82.8 percent of California's GHG emissions were carbon dioxide (CEC 2007).

- **Methane ($CH_4$).** Methane is emitted from biogenic sources (i.e., resulting from the activity of living organisms), incomplete combustion in forest fires, landfills, manure management, and leaks in natural gas pipelines. In the United States, the top three sources of methane are landfills, natural gas systems, and enteric fermentation (U.S. EPA n.d.b.). Methane is the primary component of natural gas, which is used for space and water heating, steam production, and power generation. The GWP of methane is 21.

- **Nitrous Oxide ($N_2O$).** Nitrous oxide is produced by natural and human-related sources. Primary human-related sources include agricultural soil management, animal manure management, sewage treatment, mobile and stationary combustion of fossil fuel, adipic acid production, and nitric acid production. The GWP of nitrous oxide is 310.

- **Hydrofluorocarbons (HFCs).** HFCs typically are used as refrigerants in both stationary refrigeration and mobile air conditioning. The use of HFCs for cooling and foam-blowing is growing particularly as the continued phase-out of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) gains momentum. The GWP of HFCs ranges from 140 for HFC-152a to 6,300 for HFC-236fa.

- **Perfluorocarbons (PFCs).** Perfluorocarbons are compounds consisting of carbon and fluorine. They are primarily created as a byproduct of aluminum production and semiconductor manufacturing. Perfluorocarbons are potent GHGs with a GWP several thousand times that of carbon dioxide, depending on the specific PFC. Another area of concern regarding PFCs is their long atmospheric lifetime (up to 50,000 years) (EIA n.d.). The GWPs of PFCs range from 5,700 to 11,900.

- **Sulfur Hexafluoride ($SF_6$).** Sulfur hexafluoride is a colorless, odorless, nontoxic, nonflammable gas. It is most commonly used as an electrical insulator in high voltage

equipment that transmits and distributes electricity. Sulfur hexafluoride is the most potent GHG that has been evaluated by the Intergovernmental Panel (IPCC) on Climate Change with a GWP of 23,900. However, its global warming contribution is not as high as the GWP would indicate due to its low mixing ratio, as compared to carbon dioxide (4 parts per trillion [ppt] in 1990 versus 365 parts per million [ppm] of $CO_2$) (U.S. EPA n.d.a).

The primary GHGs of concern are $CO_2$, $CH_4$, and $N_2O$, which are generally emitted from combustion activities. As forests have the potential to sequester $CO_2$, the impacts analysis in this chapter assesses potential changes to $CO_2$ sequestration as a result of the proposed project. The other GHGs listed above are related to specific industrial uses and not anticipated to be emitted in measurable or substantial quantities by the proposed project.

## Contributions to Greenhouse Gas Emissions

### *Global*

Worldwide anthropogenic (man-made) GHG emissions are tracked for industrialized nations and developing nations. Man-made GHG emissions from industrialized and developing nations are available through 2007 and 2005, respectively. The sum of these emissions totaled approximately 43,363 million metric tons of $CO_2$ equivalents ($MMTCO_2e$).[2] It should be noted that global emissions inventory data are not all from the same year and may vary depending on the source of the emissions inventory data. Emissions from the top five countries and the European Union accounted for approximately 59 percent of the total global GHG emissions, according to the most recently available data. (See Table 4.6-1, Top Five GHG Producer Countries and the European Union). The GHG emissions presented in Table 4.6-1 are representative of currently available global inventory data.

[2] The $CO_2$ equivalent emissions commonly are expressed as "million metric tons of carbon dioxide equivalent ($MMTCO_2E$)." The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP, such that $MMTCO_2E$ = (million metric tons of a GHG) x (GWP of the GHG). For example, the GWP for methane is 21. This means that the emission of one million metric tons of methane is equivalent to the emission of 21 million metric tons of $CO_2$.

**Table 4.6-1**
**Top Five GHG Producer Countries and the European Union**

| Emitting Countries | GHG Emissions ($MMTCO_2e$) |
|---|---|
| China | 7,265 |
| United States | 7,217 |
| European Union (EU), 27 Member States | 5,403 |
| Russian Federation | 2,202 |
| India | 1,877 |
| Japan | 1,412 |
| **Total** | **25,376** |

*Source: World Resources Institute, "Climate Analysis Indicators Tool (CAIT)," http://cait.wri.org/. 2010. Excludes emissions and removals from land use, land-use change and forestry (LULUCF).*
*Note: Emissions for Annex I nations are based on 2007 data. Emissions for Non-Annex I nations (e.g., China, India) are based on 2005 data.*

## *United States*

As noted in Table 4.6-1, the United States was the number two producer of global GHG emissions as of 2005. The primary GHG emitted by human activities in the United States was $CO_2$, representing approximately 85 percent of total GHG emissions. Carbon dioxide from fossil fuel combustion, the largest source of U.S. GHG emissions, accounted for approximately 80 percent of GHG emissions (U.S. EPA 2010).

## *State of California*

The California Air Resources Board (CARB) compiles GHG inventories for the State of California. Based upon the 2008 GHG inventory data (i.e., the latest year for which data are available) for the 2000-2008 greenhouse gas emissions inventory, California emitted 474 $MMTCO_2e$ ***including*** emissions resulting from imported electrical power in 2008. Based on the CARB inventory data and GHG inventories compiled by the World Resources Institute, California's total statewide GHG emissions rank second in the United States (Texas is number one) with emissions of 417 $MMTCO_2e$ ***excluding*** emissions related to imported power (CARB 2010a).

Between 1990 and 2008, the population of California grew by approximately 8.1 million (from 29.8 to 37.9 million), or 27.2 percent (California Department of Finance 2010a, U.S. Census Bureau 2010). In addition, the California economy, measured as gross state product, grew from $788 billion in 1990 to $1.8 trillion in 2008 representing an increase of approximately 128 percent (California Department of Finance 2010b). Despite the population and economic growth, California's net GHG emissions only grew by approximately 11 percent. The CEC attributes the slow rate of growth to the success of California's renewable energy programs and its commitment to clean air and clean energy (CEC 2006a).

### Effects of Global Climate Change

The primary effect of global climate change has been a rise in the average global tropospheric temperature of 0.2° Celsius per decade, determined from meteorological measurements worldwide between 1990 and 2005 (IPCC 2007). Climate change modeling using 2000 emission rates suggests that further warming is likely to occur, which would induce further changes in the global climate system during the current century (IPCC 2007). Changes to the global climate system and ecosystems, and to the proposed project site, could include:

- Declining sea ice and mountain snowpack levels, thereby increasing sea levels and sea surface evaporation rates with a corresponding increase in tropospheric water vapor due to the atmosphere's ability to hold more water vapor at higher temperatures (IPCC 2007);
- Changing weather patterns, including changes to precipitation, ocean salinity, and wind patterns, and more energetic aspects of extreme weather including droughts, heavy precipitation, heat waves, extreme cold, and the intensity of tropical cyclones (IPCC 2007);
- Declining Sierra snowpack levels, which account for approximately half of the surface water storage in California, by 70 percent to as much as 90 percent over the next 100 years (CalEPA 2006);
- Increasing the demand for electricity by 1 to 3 percent by 2020 due to rising temperatures resulting in hundreds of millions of dollars in extra expenditures (CalEPA 2006); and
- Summer warming projections in the first 30 years of the 21st century ranging from about 0.5 to 2 degrees Celsius (°C) (0.9 to 3.6 °F) and by the last 30 years of the 21st century, from about 1.5 to 5.8 °C (2.7 to 10.5 °F) (CalEPA 2006).

## 4.6.2 REGULATORY CONSIDERATIONS

### Intergovernmental Panel on Climate Change

The World Meteorological Organization (WMO) and United Nations Environmental Program (UNEP) established the IPCC in 1988. The goal of the IPCC is to evaluate the risk of climate change caused by human activities. Rather than performing research or monitoring climate, the IPCC relies on peer-reviewed and published scientific literature to make its assessment. The IPCC assesses information (i.e., scientific literature) regarding human-induced climate change, impacts of human-induced climate change, and options for adaptation and mitigation of climate change. The IPCC reports its evaluations in special reports called "assessment reports," the latest of which was published in 2007.[3] In its 2007 report, the IPCC stated that global temperature increases since the mid-20th century were "very likely" attributable to man-made activities (greater than 90 percent certainty).

[3] The IPCC's Fourth Assessment Report is available online at http://www.ipcc.ch/.

## State of California

Key state laws and regulations related to GHG emissions are described below.

### *Executive Order S-3-05 and the Climate Action Team*

In June 2005, Governor Schwarzenegger established California's GHG emissions reduction targets in Executive Order S-3-05. The Executive Order established the following goals: GHG emissions should be reduced to 2000 levels by 2010, 1990 levels by 2020, and 80 percent below 1990 levels by 2050. The Secretary of Cal EPA is required to coordinate efforts of various agencies in order to collectively and efficiently reduce GHGs. Some of the agency representatives involved in the GHG reduction plan include the Secretary of the Business, Transportation and Housing Agency, the Secretary of the Department of Food and Agriculture, the Secretary of the Resources Agency, the Chairperson of CARB, the Chairperson of the CEC, and the President of the Public Utilities Commission.

Representatives from each of the aforementioned agencies comprise the Climate Action Team. The Cal/EPA secretary is required to submit a biannual progress report from the Climate Action Team to the governor and state legislature disclosing the progress made toward GHG emission reduction targets. In addition, another biannual report must be submitted illustrating the impacts of global warming on California's water supply, public health, agriculture, coastline, and forests, and reporting possible mitigation and adaptation plans to combat these impacts. The Climate Action Team has prepared annual reports to Governor Schwarzenegger and the Legislature from 2006 (Cal EPA 2006) through 2010. Some strategies currently being implemented by state agencies include CARB introducing vehicle climate change standards and diesel anti-idling measures, the Energy Commission implementing building and appliance efficiency standards, and the Cal/EPA implementing their green building initiative. The Climate Action Team also recommends future emission reduction strategies, such as using only low-GWP refrigerants in new vehicles, developing ethanol as an alternative fuel, reforestation, solar power initiatives for homes and businesses, and investor-owned utility energy efficiency programs. According to the report, implementation of current and future emission reduction strategies have the potential to achieve the goals set forth in Executive Order S-3-05.

### *Senate Bill 97 (CEQA Guidelines)*

On August 24, 2007, California Senate Bill No. 97 was signed into law. The bill required the Governor's Office of Planning and Research to develop, and the Natural Resources Agency to adopt, amendments to the CEQA guidelines addressing the analysis and mitigation of GHG emissions. These guidelines included, among others, that lead agencies must analyze the GHG emissions of proposed projects, and must reach a conclusion regarding the significance of those emissions (CCR§ 15064.4). In addition, when a project's GHG emissions may be significant, lead agencies must consider a range of potential mitigation measures to reduce those emissions (CCR§ 15126.4(c)).

The March 2010 revisions to the CEQA guidelines drafted and issued by the California Natural Resources Agency require that all projects that are subject to CEQA review must include an analysis of climate change and GHG impacts. This analysis must include a determination as to whether the project's impacts are significant and, if they are significant, must include mitigation. The California Air Resources Board (ARB) has not published significance thresholds for GHGs.

### *Assembly Bill 32*

In furtherance of the goals established in Executive Order S-3-05, the legislature enacted Assembly Bill 32 (AB 32, Nuñez and Pavley), the California Global Warming Solutions Act of 2006, which Governor Schwarzenegger signed on September 27, 2006. AB 32 represents the first enforceable statewide program to limit GHG emissions from all major industries with penalties for noncompliance. AB 32 requires the State to undertake several actions – the major requirements are discussed below:

In addition to CEQA guidance, the California Environmental Protection Agency Climate Action Team (CAT) and the California ARB have developed several reports to achieve the Governor's GHG targets that rely on voluntary actions of California businesses, local government and community groups, and State incentive and regulatory programs. These include the CAT's annual "*Report to Governor Schwarzenegger and the Legislature*," ARB's 2007 "*Expanded List of Early Action Measures to Reduce Greenhouse Gas Emissions in California*," and ARB's "*Climate Change Proposed Scoping Plan: a Framework for Change"* (Scoping Plan). The reports identify strategies to reduce California's emissions to the levels proposed in Executive Order S-3-05 and California Assembly Bill 32 (hereafter AB 32), the Global Warming Solutions Act.

Pursuant to the requirements of AB 32, ARB prepared the Scoping Plan to demonstrate how the 2020 reduction target can be met. The Scoping Plan was adopted in December 2008 and defined broad goals and measures to achieve the objectives for various industry sectors (CARB 2008). Multiple sectors are identified in the plan including transportation, electricity, and industry; the sector relevant to this project is the forest sector. The forest sector is unique in that it is the only sector that removes $CO_2$ from the atmosphere and sequesters it over the long-term. However, several factors, such as large wildfires and forest land conversion, may cause a decline in the amount of carbon removed from the atmosphere (Cal EPA 2006). The forest sector strategy is a "No Net Loss" target, which would achieve reductions equivalent to the current statewide forest carbon budget (5 million metric tons of $CO_2e$ emissions), by preserving forest sequestration through sustainable management practices (CARB 2008).

The Scoping Plan provides policies, guidelines and recommendations to manage fuels and protect wildlands in a manner consistent with State strategies and long-term climate goals. While some of these activities (e.g., tree removal and prescribed burning) may appear to conflict with short-term GHG emission reduction goals, the State and District expect that implementation of the Scoping Plan recommendations will reduce long-term emissions (e.g., emissions associated with catastrophic and damaging wildfires) and result in larger net gains in vegetation health

(California Board of Forestry and Fire Protection 2008). Tree removal and thinning or brush clearing may cause short term emissions (through the use of vehicles to transport personnel and mechanical equipment) and loss of some carbon sequestered in vegetation, but these emissions are expected to be offset by the growth promotion and regeneration of native and (generally) low fire hazard vegetation. However, quantifying the specific GHG benefits associated with avoiding wildfire through fuels treatment is speculative because of the unpredictable nature of fire.

### *AB 32 Climate Change Scoping Plan*

As indicated above, AB 32 requires CARB to adopt a scoping plan indicating how reductions in significant GHG sources will be achieved through regulations, market mechanisms, and other actions. After receiving public input on their discussion draft of the *Climate Change Proposed Scoping Plan* released in June 2008, CARB released the *Climate Change Proposed Scoping Plan* in October 2008 that contains an outline of the proposed state strategies to achieve the 2020 greenhouse gas emission limits. The CARB Governing Board approved the *Climate Change Scoping Plan* on December 11, 2008. Key elements of the Scoping Plan include the following recommendations:

- Expanding and strengthening existing energy efficiency programs as well as building and appliance standards;
- Achieving a statewide renewable energy mix of 33 percent;
- Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system;
- Establishing targets for transportation-related greenhouse gas emissions for regions throughout California and pursuing policies and incentives to achieve those targets;
- Adopting and implementing measures pursuant to existing state laws and policies, including California's clean car standards, goods movement measures, and the Low Carbon Fuel Standard; and
- Creating targeted fees, including a public goods charge on water use, fees on high global warming potential gases, and a fee to fund the administrative costs of the state's long-term commitment to AB 32 implementation.

Under the Scoping Plan, approximately 85 percent of the state's emissions are subject to a cap-and-trade program where covered sectors are placed under a declining emissions cap. The emissions cap incorporates a margin of safety whereas the 2020 emissions limit will still be achieved even in the event that uncapped sectors do not fully meet their anticipated emission reductions. Emissions reductions will be achieved through regulatory requirements and the option to reduce emissions further or purchase allowances to cover compliance obligations. It is expected that emission reduction from this cap-and-trade program will account for a large portion of the reductions required by AB 32.

Table 4.6-2, AB 32 Scoping Plan Measures (SPMs), lists CARB's preliminary recommendations for achieving greenhouse gas reductions under AB 32 along with a brief description of the requirements and applicability.

**Table 4.6-2**
**AB 32 Scoping Plan Measures (SPMs)**

| Scoping Plan Measure | Description |
|---|---|
| **SPM-1**: California Cap-and-Trade Program linked to Western Climate Initiative | Implement a broad-based cap-and-trade program that links with other Western Climate Initiative Partner programs to create a regional market system. Ensure California's program meets all applicable AB 32 requirements for market-based mechanisms. Capped sectors include transportation, electricity, natural gas, and industry. Projected 2020 business-as-usual emissions are estimated at 512 $MTCO_2e$; preliminary 2020 emissions limit under cap-and-trade program are estimated at 365 $MTCO_2e$ (29 percent reduction). |
| **SPM-2:** California Light-Duty Vehicle GHG Standards | Implement adopted Pavley standards and planned second phase of the program. AB 32 states that if the Pavley standards (AB 1493) do not remain in effect, CARB shall implement equivalent or greater alternative regulations to control mobile sources. |
| **SPM-3**: Energy Efficiency | Maximize energy efficiency building and appliance standards, and pursue additional efficiency efforts. The Scoping Plan considers green building standards as a framework to achieve reductions in other sectors, such as electricity. |
| **SPM-4**: Renewables Portfolio Standard | Achieve 33 percent Renewables Portfolio Standard by both investor-owned and publicly owned utilities. |
| **SPM-5**: Low Carbon Fuel Standard | CARB identified the Low Carbon Fuel Standard as a Discrete Early Action item and the final regulation was adopted on April 23, 2009. In January 2007, Governor Schwarzenegger issued Executive Order S-1-07, which called for the reduction of the carbon intensity of California's transportation fuels by at least 10 percent by 2020. |
| **SPM-6**: Regional Transportation-Related Greenhouse Gas Targets | Develop regional greenhouse gas emissions reduction targets for passenger vehicles. SB 375 requires CARB to develop, in consultation with metropolitan planning organizations (MPOs), passenger vehicle greenhouse gas emissions reduction targets for 2020 and 2035 by September 30, 2010. SB 375 requires MPOs to prepare a sustainable communities strategy to reach the regional target provided by CARB. |
| **SPM-7**: Vehicle Efficiency Measures | Implement light-duty vehicle efficiency measures. CARB is pursuing fuel-efficient tire standards and measures to ensure properly inflated tires during vehicle servicing. |
| **SPM-8**: Goods Movement | Implement adopted regulations for port drayage trucks and the use of shore power for ships at berth. Improve efficiency in goods movement operations. |
| **SPM-9**: Million Solar Roofs Program | Install 3,000 MW of solar-electric capacity under California's existing solar programs. |
| **SPM-10**: Heavy/Medium-Duty Vehicles | Adopt heavy- and medium-duty vehicle and engine measures targeting aerodynamic efficiency, vehicle hybridization, and engine efficiency. |

| Scoping Plan Measure | Description |
|---|---|
| **SPM-11**: Industrial Emissions | Require assessment of large industrial sources to determine whether individual sources within a facility can cost-effectively reduce greenhouse gas emissions and provide other pollution reduction co-benefits. Reduce greenhouse gas emissions from fugitive emissions from oil and gas extraction and gas transmission. Adopt and implement regulations to control fugitive methane emissions and reduce flaring at refineries. |
| **SPM-12**: High Speed Rail | Support implementation of a high-speed rail (HSR) system. This measure supports implementation of plans to construct and operate a HSR system between Northern and Southern California serving major metropolitan centers. |
| **SPM-13**: Green Building Strategy | Expand the use of green building practices to reduce the carbon footprint of California's new and existing inventory of buildings. |
| **SPM-14**: High GWP Gases | Adopt measures to reduce high global warming potential gases. The Scoping Plan contains 6 measures to reduce high-GWP gases from mobile sources, consumer products, stationary sources, and semiconductor manufacturing. |
| **SPM-15**: Recycling and Waste | Reduce methane emissions at landfills. Increase waste diversion, composting, and commercial recycling. Move toward zero-waste. |
| **SPM-16**: Sustainable Forests | Preserve forest sequestration and encourage the use of forest biomass for sustainable energy generation. The federal government and California's Board of Forestry and Fire Protection have the regulatory authority to implement the Forest Practice Act to provide for sustainable management practices. This measure is expected to play a greater role in the 2050 goals. |
| **SPM-17**: Water | Continue efficiency programs and use cleaner energy sources to move water. California will also establish a public goods charge for funding investments in water efficiency that will lead to as yet undetermined reductions in greenhouse gases. |
| **SPM-18**: Agriculture | In the near-term, encourage investment in manure digesters and at the five-year Scoping Plan update determine if the program should be made mandatory by 2020. Increase efficiency and encourage use of agricultural biomass for sustainable energy production. CARB has begun research on nitrogen fertilizers and will explore opportunities for emission reductions. |

*Source: California Air Resources Board, Climate Change Scoping Plan, (2008).*

### *California Air Resources Board*

CARB is responsible for carrying out and developing the programs and requirements necessary to achieve the goal of AB 32—the reduction of California's GHG emissions to 1990 levels by 2020. The first action under AB 32 resulted in CARB's adoption of a report listing three specific early action greenhouse gas emission reduction measures on June 21, 2007. On October 25, 2007, CARB approved an additional six early action GHG reduction measures under AB 32. CARB has adopted regulations for all early action measures. The early action measures are divided into three categories:

- Group 1 – GHG rules for immediate adoption and implementation
- Group 2 – Several additional GHG measures under development
- Group 3 – Air pollution controls with potential climate co-benefits

The original three adopted early action regulations meeting the narrow legal definition of "discrete early action GHG reduction measures" include:

- A low-carbon fuel standard to reduce the "carbon intensity" of California fuels;
- Reduction of refrigerant losses from motor vehicle air conditioning system maintenance to restrict the sale of "do-it-yourself" automotive refrigerants; and
- Increased methane capture from landfills to require broader use of state-of-the-art methane capture technologies.

The additional six early action regulations adopted on October 25, 2007, also meeting the narrow legal definition of "discrete early action GHG reduction measures," include:

- Reduction of aerodynamic drag, and thereby fuel consumption, from existing trucks and trailers through retrofit technology;
- Reduction of auxiliary engine emissions of docked ships by requiring port electrification;
- Reduction of perfluorocarbons from the semiconductor industry;
- Reduction of propellants in consumer products (e.g., aerosols, tire inflators, and dust removal products);
- The requirement that all tune-up, smog check and oil change mechanics ensure proper tire inflation as part of overall service in order to maintain fuel efficiency; and
- Restriction on the use of sulfur hexafluoride (SF6) from non-electricity sectors if viable alternatives are available.

In addition to the 1990 emissions inventory, CARB also adopted regulations requiring the mandatory reporting of GHG emissions for large facilities on December 6, 2007. The mandatory reporting regulations require annual reporting from the largest facilities in the state, which account for approximately 94 percent of point source greenhouse gas emissions from industrial and commercial stationary sources in California. About 800 separate sources fall under the new reporting rules and include electricity-generating facilities, electricity retail providers and power marketers, oil refineries, hydrogen plants, cement plants, cogeneration facilities, and industrial sources that emit over 25,000 tons of carbon dioxide each year from on-site stationary combustion sources. Transportation sources, which account for 38 percent of California's total greenhouse gas emissions, are not covered by these regulations but will continue to be tracked through existing means. Affected facilities will begin tracking their emissions in 2008, to be reported beginning in 2009, with a phase-in process to allow facilities to develop reporting systems and train personnel in data collection. Emissions for 2008 may be based on best available emission data. Beginning in 2010, however, emissions reporting requirements will be more rigorous and will be subject to third-party verification. Verification will take place annually or every three years, depending on the type of facility.

### *State of California Greenhouse Gas Inventory and 2020 Limit*

As required under AB 32, on December 6, 2007, CARB approved the 1990 greenhouse gas emissions inventory, thereby establishing the emissions limit for 2020. The 2020 emissions limit was set at 427 $MMTCO_2e$. CARB also projected the state's 2020 GHG emissions under "business as usual" (BAU) conditions—that is, emissions that would occur without any plans, policies, or regulations to reduce GHG emissions. CARB used an average of the State's GHG emissions from 2002 through 2004 and projected the 2020 levels based on population and economic forecasts. The projected net emissions totaled approximately 596 $MMTCO_2e$. Therefore, the state must reduce its 2020 BAU emissions by approximately 29 percent in order to meet the 1990 target.

The inventory revealed that in 1990, transportation, with 35 percent of the state's total emissions, was the largest single sector, followed by industrial emissions, 24 percent; imported electricity, 14 percent; in-state electricity generation, 11 percent; residential use, 7 percent; agriculture, 5 percent; and commercial uses, 3 percent (these figures represent the 1990 values, compared to Table 4.6-2, which presents 2006 values). AB 32 does not require individual sectors to meet their individual 1990 GHG emissions inventory; the total statewide emissions are required to meet the 1990 threshold by 2020.

## Regional and Local

### *Bay Area Air Quality Management District*

The Bay Area Air Quality Management District (BAAQMD), the regional air quality board presiding over San Francisco, has jurisdiction over GHG emissions in the Bay Area. BAAQMD's CEQA guidelines, finalized in May 2011, set a threshold for operational emissions of 10,000 metric tons of CO2 equivalent (or $MTCO_2e$) per year for stationary sources and a 1,100 $MTCO_2e$ per year threshold for other land use projects. On March 5, 2012 the Alameda County Superior Court issued a judgment finding that the Air District had failed to comply with CEQA when it adopted the thresholds. The court did not determine whether the thresholds were valid, but found that the adoption of the thresholds was a project under CEQA. The court issued a writ of mandate ordering the District to set aside the thresholds and cease dissemination of them until the Air District had complied with CEQA (BAAQMD 2012). At present, the thresholds are not being recommended for use by the BAAQMD.

### *University of California Policy on Sustainable Practices*

The University of California Policy on Sustainable Practices is a system-wide commitment to minimize the University of California's impact on the environment and reduce the University's dependence on non-renewable energy sources. The University of California Policy on Sustainable Practices promotes the principles of energy efficiency and sustainability in the areas of Green Building Design; Clean Energy Standard; Climate Protection Practices; Sustainable Transportation Practices; Sustainable Operations; Recycling and Waste Management;

Environmentally Preferable Purchasing Practices; and Food, all of which help reduce GHG emissions from University operations.

The Policy notes "these guidelines currently recommend that University operations:

- Incorporate the principles of energy efficiency and sustainability in all capital projects, renovation projects, operations and maintenance within budgetary constraints and programmatic requirements.

- Minimize the use of non-renewable energy sources on behalf of the University's built environment by creating a portfolio approach to energy use, including the use of local renewable energy and purchase of green power from the grid as well as conservation measures that reduce energy consumption.

- Incorporate alternative means of transportation to/from and within the campus to improve the quality of life on campus and in the surrounding community. The campuses will continue their strong commitment to provide affordable on-campus housing, in order to reduce the volume of commutes to and from campus. These housing goals are detailed in the campuses' Long Range Development Plans.

- Track, report and minimize greenhouse gas emissions on behalf of University operations.

- Minimize the amount of University-generated waste sent to landfill.

- Utilize the University's purchasing power to meet its sustainability objectives."

### *UCSF Climate Action Plan*

UCSF published its Climate Action Plan (CAP) in December of 2009 in order to comply with the UC Policy on Sustainable Practices as well as meet the requirements of the American Colleges and University Presidents Climate Commitment (ACUPCC), of which the UC system is a signatory. The UCSF CAP includes the UCSF GHG emissions baseline and projected inventories, sustainability efforts to date, and future reduction efforts. The CAP informs practices throughout the campus including procurement, building operation and design, transportation, recycling and education. Through its participation in the ACUPCC, UCSF is committed to reduce its GHG emissions from all of its operations to the 1990 level by 2020, with the eventual goal of achieving carbon neutrality for the campus. As part of this emissions reduction effort, UCSF regularly reports to the ACUPCC its emissions, progress towards reduction goals, and measures used or proposed to meet these goals.

## 4.6.3 BIOTIC CARBON SEQUESTRATION

Carbon sequestration is the process by which atmospheric carbon dioxide is absorbed by trees through photosynthesis and stored as carbon in trunks, branches, foliage, roots and soils. Carbon sequestration in terrestrial ecosystems is defined as the net removal of carbon dioxide from the atmosphere into long-lived stocks of carbon (Shaw et al 2009). Forests serve as large reservoirs of sequestered carbon as well as potential carbon sinks[4] and sources to the atmosphere. In the United States, forest carbon sinks have been estimated to offset up to 24 percent of the fossil fuel source (Bosquet et al 2000).

Forests store carbon in virtually all of their components: soils, litter (forest floor), and understory, as well as trees (Wayburn et al 2000). Forest-soil carbon is a large, stable pool, accounting for some 50% of the total forest carbon and changing very slowly over hundreds of years (Kimmons 1997). For timeframes of 100 years and less, forest accounting can ignore this pool and focus on changes to more labile forest carbon components. The vast majority of forest carbon accumulation is from photosynthesis by trees, with understory accounting for 5% or less (Kimmons 1997). Therefore, accumulation of carbon through tree growth and the release of carbon from timber harvest, including from decay of dead material constitutes the primary accounting focal points (Wayburn et al 2000). This sink must be quantified to determine how a project will impact GHG emissions.

### Methodology and Setting

The current above-ground carbon sink associated with the vegetation in the project area was measured using ground-based data for the entire 61 acre Reserve. The carbon content was investigated for the live tree, dead standing tree, and fallen log (i.e., downed woody debris or DWD) carbon pools.

The Reserve is covered by a dense stand of trees, with the exception of the Rotary Meadow at the summit clearing. The Reserve is dominated (82%) by blue-gum eucalyptus (*Eucalyptus globulus*), planted in the late 1800s. Other tree species include Monterey pine (*Pinus radiata*), Monterey cypress *(Cupressus macrocarpa*), blackwood acacia (*Acacia melanoxylon*), and coast redwood (*Sequoia sempervirens*) (Hortscience 1999, UCSF 2010). The understory is thick with Himalayan blackberry, other nonnative and native shrubs and vines, many of which grow on tree trunks. Though largely undeveloped, the Reserve is adjacent to the main developed portion of the campus and surrounds the UCSF's Aldea Housing complex as well as the Chancellor's residence (UCSF 2010).

To investigate the above-ground carbon stored in the Reserve, forest stand structure and stand composition were measured. To capture the variability across the Reserve, variable slopes,

[4] A carbon sink is any reservoir that can accumulate and store carbon in the form of a chemical compound for an indefinite period of time. Trees are carbon sinks, as they sequester carbon in the form of biomass synthesized from atmospheric $CO_2$.

aspects and topographies were sampled across the geographic spread of the project area (see Figure 1). Field surveys were conducted on March 28th, March 29, April 4th and April 14th, 2012.

Six fixed area plots with an area of one-tenth acre and a radius of 37.2 feet were established. Diameter and species for all live and dead standing stems greater than five inches diameter at breast height (DBH) were taken outside of the bark. Downed logs were located, identified to species (when possible), and their length (as a proxy for height) and diameter were measured. Slope, aspect, and elevation were recorded at plot center. Panoramic photos of the six plots were taken from plot center (see Appendix A).

Tree species found in the six vegetation plots were: blue-gum eucalyptus, Monterey cypress, blackwood acacia, and ornamental *Prunus* sp. Other trees species observed in the Reserve, but that did not fall into the vegetation plots, were coast redwood, Monterey pine, and coast live oak (*Quercus agrifolia*).

Volume, biomass and carbon calculations to estimate carbon sequestration across the Reserve can be found in Appendix F.

A total of 38,918 tons of $CO_2e$ (35,306 metric tons of $CO_2e$), or 639 tons per acre of $CO_2e$ (579 metric tons of $CO_2e$ per acre), is sequestered in the above-ground live and dead tree biomass of the Mount Sutro Open Space Reserve. Of this, approximately 98.76% is sequestered in the Reserve's live blue-gum eucalyptus trees. Dead standing and dead fallen logs, all of which were identified as blue-gum eucalyptus, comprised less than 1% (0.23% and 0.39%, respectively) of the $CO_2e$ in the Reserve.

The average DBH of all live trees measured was 14.2 inches; the average for blue-gum eucalyptus was slightly higher at 14.6 inches. Forty five percent of all live trees were measured at greater than 12 inches DBH, with the remaining 55% between 5 and 12 inches DBH.

Overall, these results constitute a conservative estimate of above-ground carbon sink within the Reserve as they do not factor the shrub or forest floor layer (e.g. duff and litter); these pools, however, constitute less than 5% of the average forest carbon pool. Consistent with other studies, carbon stored in the soil (greater than 50% of the Reserve's total carbon pool) was not measured; it was assumed to be at equilibrium over time and unaffected by the Alternatives.

### 4.6.4 EQUIPMENT OPERATIONS

In addition to the reduction of the biotic carbon sink within the Reserve, some of the equipment operation activities would be potential sources of GHGs. To accomplish the proposed tree thinning, UCSF would employ a single Brontosaurus mower, a chipper, and a yarder. Work would commence first in the four Demonstration projects (see Section 3.5 Project Description for a discussion of Demonstration projects); each of the Demonstration projects would be completed in 2-10 days. When funding becomes available, the proposed management activities across the entire Reserve would follow in phases.

This analysis of GHG emissions considers the impacts associated with the proposed project during project implementation. Pursuant to Section 15064.4 of the CEQA Guidelines, the significance of the project's GHG emissions has been determined based on whether the proposed project's emissions would exceed levels outlined in any applicable GHG-reduction plans, policies, or regulations.

Vegetation management-related effects on GHG emissions relate strictly to direct and indirect impacts that could occur during management activities, such as the removal of dead, dying, unhealthy or hazardous trees. Implementation-related GHG emissions were analyzed using the California Air Resources Board (CARB) OFFROAD model. Only $CO_2e$ were estimated, because CH4 and N2O emissions from diesel-fueled equipment account for approximately 2% of total emissions, even when converted to carbon dioxide equivalent (EPA 2012b).

Due to the nature of the project, there are no operational impacts associated with the project. There would be no new emission sources added; therefore, operation-related effects on air quality are not analyzed further. For the purposes of the document, it was assumed that any maintenance activities planned following the proposed project would be minimal and would not raise emissions beyond a significant level.

## 4.6.5 SIGNIFICANCE STANDARDS AND ANALYSIS METHODOLOGY

This section evaluates impacts to greenhouse gas (GHG) sources and sinks associated with the proposed management activities across the 61 acre forested portion of the UCSF Mount Sutro Open Space Reserve. It includes a description and analysis of 1) proposed vegetation management activities (e.g. tree thinning) and, 2) source emissions associated with vegetation management activities. Where appropriate, it identifies feasible mitigation measures to reduce potentially significant impacts to a less than significant level. Section 4.6.3 Biotic Carbon Sequestration, and Section 4.6.4, Equipment Operations, provide the basis for the assessment of these impacts.

### Significance Criteria

In accordance with Senate Bill (SB) 97, the Natural Resources Agency adopted amendments to the State CEQA Guidelines on December 30, 2009 (effective March 2010), which include criteria for evaluating GHG emissions[5]. According to the amended Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment if it would:

- Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment; or

[5] http://ceres.ca.gov/ceqa/guidelines/

- Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases.

The amended *State CEQA Guidelines* include a new Section 15064.4, which states that, when making a determination of the significance of GHG emissions, a lead agency shall have discretion to determine whether to: (1) Use a model or methodology to quantify greenhouse gas emissions resulting from a project, and which model or methodology to use; and/or (2) Rely on a qualitative analysis or performance based standards.

Section 15064.4 also states that a lead agency should consider the following factors when assessing the significance of GHG emissions on the environment: (1) The extent to which the project may increase or reduce greenhouse gas emissions as compared to the existing environmental setting; (2) Whether the project emissions exceed a threshold of significance that the lead agency determines applies to the project; and (3) The extent to which the project complies with regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of greenhouse gas emissions.

As discussed previously, there are no quantitative standards of significance established by regulatory agencies that would apply to the proposed project. Therefore, for purposes of this analysis, the proposed project is considered to have a significant effect on the environment if it would (1) substantially affect the ability of the Reserve to sequester GHGs, (2) generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment, or (3) conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing emissions of GHGs.

With regard to equipment operations during project implementation, the BAAQMD thresholds of significance include a threshold for operational GHG emissions but none for construction-related GHG emissions. BAAQMD recommends the significance of GHG construction-related emission impacts be determined in relation to meeting AB 32 GHG reduction targets. BAAQMD further recommends, and encourages lead agencies to incorporate best management practices (BMPs) to reduce GHG emissions during construction, when it is feasible and applicable. BMPs could include, but are not limited to: adhering to BAAQMD idling regulations for diesel, composting of removed vegetation on-site, ensuring that equipment is properly maintained, providing that at least 15 percent of the operational fleet be comprised of alternatively fueled (e.g., biodiesel, electric) vehicles and equipment, using at least 10 percent local building materials, or recycling or reusing at least 50 percent of waste or demolition materials.

## Methodology

UCSF proposes to incrementally thin portions of the Reserve's forest. Thinning is proposed where trees are particularly dense, except on western slopes where the terrain is too steep or otherwise inaccessible. Based on these parameters, thinning would occur on 46 of the 61 acres of the project area; the remaining 15 acres of terrain are too steep to thin (UCSF 2010).

Projected thinning would achieve an average of 30 foot spacing between trees; the priority for removal would be dead, dying, unhealthy, and hazardous trees. Where trees must be removed to achieve desired spacing, the next priority would be trees smaller than 12 inches in diameter. In addition, all nonnative shrubs (and the native poison oak) would be removed from the understory throughout the entire Reserve (UCSF 2010).

UCSF proposes to keep much of the vegetation removed through thinning and clearing on-site. Large felled trees would be left on-site and smaller trees would be used on-site as mulch. Little, if any, material would be taken to landfill (UCSF 2010).

Both a short-term (1 year post-thinning) and long-term (30 year post-thinning) scenario is evaluated. While impacts associated with short-term scenarios have been quantified, long-term scenarios, by virtue of being 30 years in the future, are more speculative.

Currently, approximately 38,918 tons of $CO_2e$ is sequestered in the live tree, standing dead tree, and downed tree carbon pools (see Section 4.6.3 Biotic Carbon Sequestration).

### *Short-term Scenario*

Under short-term conditions with the proposed project, the Reserve's above-ground carbon sink would be reduced by a maximum of 29%, or 11,286 tons of $CO_2e$ (10,239 metric tons). See Appendix F for calculations.

### *Long-term Scenario*

Under long-term conditions with the proposed project, the Reserve is expected to sequester more carbon and eventually recoup much of the carbon lost in the thinning treatment. Additional carbon sequestration would occur through release from competition (driven by the decreased density of standing trees) of trees that are left post-treatment. It would also occur through increased regeneration from the understory as saplings and small trees left post-treatment are released from competition for light, water, and nutrients. Finally, the risk of fire would be reduced with the proposed project as compared to existing conditions or doing nothing (the No Project Alternative – see Chapter 6). Forest fires contribute to reductions in carbon sequestration and result in the release of substantial amounts of sequestered carbon.

*Assumption #1*: Standing trees are projected to be 'released' and to experience increased growth due to the substantial decrease in tree density. In addition, reduced tree mortality would be expected compared to doing nothing (the No Project Alternative).

Young, healthy forests absorb carbon more rapidly than older, dense forests (Wayburn 2010). A stand's average yearly growth since stand initiation is referred to as its mean annual increment (MAI); MAI is a function of tree age, density, and site characteristics (Rinehart and Standiford 1983). The Reserve is dominated by mature blue-gum eucalyptus forest that was planted in the late 1800's (Hortscience 1999). At young ages, blue-gum eucalyptus is one of the fastest growing eucalypts. A three-year-old tree has been recorded at 46 feet high and 0.74 feet in diameter. At 30

years, it has been recorded at 164 feet high and 3.28 to 6.56 feet in diameter (McClatchie 1902). However, it is assumed here that the age of the Reserve's largest trees (>115 years old) exceeds the age at which eucalypts continues to add significant annual increment or diameter (or height), particularly in the absence of tree density changes that might affect a release from competition. Though numerous articles document growth and yield curves for blue-gum eucalyptus (McClatchie 1902, Borough et al 1978, Rinehart and Standiford 1983), none do so for blue-gum greater than 40 years in age (Rinehart and Standiford 1983). Such research papers are timber- and harvest-oriented and advise harvest of blue-gum between 12 to 30 years of age. These lines of evidence suggest that the Reserve's mature eucalyptus are well past peak growth, and are no longer sequestering much if any additional carbon. As the forest is predominantly comprised of eucalyptus species (82%), it is assumed that predominantly eucalyptus species will be felled. The reduced growth rate of these mature/dying trees implies that the annual sink 'deferential', representing the opportunity cost of additional carbon that would have been sequestered each year by the growth of trees that were instead felled, would be more than compensated by the additional growth of remaining trees and understory recruitment as a result of thinning efforts.

At this time, reports suggest that ongoing mortality is occurring in the Reserve, and that mortality can be expected to continue and potentially increase as the stand age of the forest increases. One such line of evidence is that the current forest in the Reserve contains a significant volume of downed wood. The 1999 HortScience report states that:

> "tree failures by uprooting were observed across the site. Failures among all tree species except for coast redwood were observed but the greatest number of root failures were blue gum. Failures appeared to be caused by windthrow that lifted the root placate and soil out of the ground. Tim Lipinski noted that a series of failures had occurred on the south slope of Mount Sutro several years ago. We observed numerous fallen trees on all slope aspects."

This suggests that tree mortality is occurring, and even if the rate of mortality remains constant, additional trees would be expected to die over the 30 year-period. As trees die, they cause a decrease in forest carbon sequestration releasing carbon to the atmosphere through decay (Harmon et al 1990).

In addition, pest and disease outbreaks slow growth and therefore slow carbon accumulations. If mortality results, they lead to increased decomposition, which releases carbon into the atmosphere. In the Reserve, outbreaks by the eucalyptus snout beetle (*Gonipterus scutellatus*) have been recorded the last three summer and fall seasons in the Reserve (J. Sutton pers comm). Larvae and adult beetles consume eucalyptus leaves, weakening the trees. Pest (as well as a pathogen) outbreaks are density-dependent; that is, they cause more harm in dense forests where trees tend to be stressed through competition for water, nutrients, and light. Mortality from pests such as the snout beetle is therefore expected to be lowered with the thinned forest as proposed by the project, compared to existing conditions.

*Assumption #2*: More understory recruitment would be expected due to the reduction in tree density post-thinning and the incumbent reduction in competition for light, water and nutrients. In addition, UCSF proposes to remove some or all of the understory ground cover (e.g. blackberry, ivy) which directly competes with and reduces the colonizable surface available to tree seedlings (Hortscience 1999).

The Hortscience arboriculture report states the following:

> "Regeneration in the existing tree canopy is limited and may be problematic for the future. While we observed many saplings of blue gum, their overall condition was poor. Most of the standing dead trees observed in our study were less than 6'' in diameter. The rampant growth of English ivy, blackberry, and other groundcover species appears to be impeding regeneration of blue gum and its recruitment into the overstory. There appeared to be little regeneration in gaps in the canopy created by tree failure. Among tree species other than blue gum, only blackwood acacia appeared to be regenerating[6]."

In the absence of thinning, recruitment patterns would be expected to be similarly limited at 30 years compared to the short-term scenario. Some regeneration into the tree canopy may occur in tree-fall gaps left by dying trees, for instance in areas where beetle or pathogen outbreaks kill additional trees. Due to the complications of plant interactions and the uncertainty of future mortality, it is difficult to quantify the amount of recruitment expected. However, more recruitment into the understory is projected with the project compared to existing conditions.

*Assumption #3*: The proposed project would reduce tree density and remove dead standing snags, both of which would reduce the risk of fire in the Reserve compared to existing conditions or doing nothing. As the majority of felled trees would be left as either logs or mulch on the forest floor, there will be an increase in the forest floor fuel load. However, on balance, the proposed project is expected to have a reduced impact on fire potential compared to existing conditions or doing nothing.

In California, blue-gum eucalyptus stands are highly susceptible to fire during the dry season. The bark, which hangs in strips from the stems, readily carries fire into the crowns, and the leaves contain volatile oils that produce a hot fire (FAO 1979). Though San Francisco's climate is moister than in most parts of California, this is still a factor in fire probability. As described in Assumption #1, a denser forest can result in increased tree mortality through both pest and pathogen outbreaks and increased stress of standing trees due to inter-specific competition for light, water and nutrients. The downed wood that results can increase fuel loading in the Reserve, increasing the chances of a fire event. This suggests that the probability of fire would be reduced with the proposed project compared to existing conditions or doing nothing, which is consistent with the project's objective of reducing fire risk through tree-thinning. However, because felled large trees and mulched smaller trees would be retained on-site under the

[6] See Appendix F for $CO_2e$ sequestered in lb/acre by species.

proposed project, fuel load will be increased across the Reserve, thus maintaining some degree of fire risk.

## 4.6.6 IMPACTS AND MITIGATION MEASURES

**Impact GHG-1: Proposed vegetation management activities would affect the ability of the Reserve to sequester GHGs, but not at levels that would result in a significant impact on the environment. (Less than Significant)**

The proposed project would result in the short-term reduction of 29%, or 11,286 tons of $CO_2e$ (10,239 metric tons) of the Reserve's above-ground carbon sink compared to the baseline. As discussed in Section 4.6.2 (Regulatory Considerations), the BAAQMD GHG significance thresholds under CEQA have been challenged, and even if those thresholds were approved for analysis again, they would not apply to the proposed project (personal communication with Alison Kirk, BAAQMD). However, of the regulated categories of emissions, from stationary sources or from land use sources, this project most resembles the land use source and is evaluated based on the threshold values associated with land use (i.e., 1,100 metric tons of $CO_2$). The requirements for stationary sources are not used in the analysis because the project does not meet the definition of a stationary source, which is defined as a non-moving source or fixed-site producer of pollution (e.g. power plants, chemical plants, oil refineries, manufacturing facilities, and other facilities [EPA 2012a]).

To compare the reduction in the above-ground carbon sink to land use thresholds, the removal of the sink must be considered over the 30-year lifespan of the project. This is because the land use thresholds are developed for annual emissions while the removal of the sink is a one-time activity as opposed to emissions over a project's life-time. In order to compare a one-time activity to operational thresholds, the GHG emissions associated with land use, the impacts of the removal of the carbon sink must be amortized over the lifespan of the project (30 years). This decreases annual impacts from the sink removal to 376 tons, 341 metric tons, per year (11,286 tons divided by 30 years), which is less than the land use threshold of 1,100 metric tons.

In addition, under the long term scenario, the projected increased growth of trees left post-thinning, the net gains in forest health (e.g. associated with reduced pest or pathogen infestations) leading to reduced tree mortality, and the increased probability for understory tree recruitment would be expected to offset much or all of the short-term carbon loss. The proposed project appears to conflict with short-term GHG emission goals but the larger gains in the long-term scenario are expected to offset much or all of the short-term loss. Given these factors, the level of reduction of GHG sequestration that would occur under the proposed vegetation management activities is considered less than significant.

**Impact GHG-2: Proposed vegetation management activities would not conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing GHG emissions. (Less than Significant)**

As discussed above, the reduction in the carbon sink when amortized over the life of the project would be less than the proposed BAAQMD land use emissions thresholds. Given the discussion presented above, the proposed project's GHG emissions under CEQA are determined to be less than significant.

With regards to AB-32 Scoping Plan Measure 16, which addresses sustainable forests, the proposed project would not conflict with the sustainable management practices under the Forest Act, as the Act is targeted more towards larger-scale logging practices. No significance thresholds have been adopted for vegetation management projects under Executive Order S-3-05 and the State's AB 32 goals at this time. Section 4.6.2 outlines the stated goals for these two documents. The proposed project would not conflict with either Executive Order S-3-05 or the State's AB 32 goal and associated Scoping Plan estimates of reducing GHG emissions to 1990 levels by 2020, and the proposed project's GHG emissions are found to be less than significant.

**Impact GHG-3: Equipment operations associated with project implementation would generate GHG emissions, but not at levels that would result in a significant impact on the environment. (Less than Significant)**

Exhaust emissions from off-road equipment are expected to contribute minimally to long-term regional increases in GHGs. Table 4.6-3 presents the project's estimated total implementation-related emissions for 2012 and 2013. As indicated in the table, implementation activities associated with the project would generate up to an estimated 5.7 MT of CO2e during the implementation of the project (assumed to be sometime in 2013). Emissions associated with equipment operation during implementation would be extremely small, representing less than 0.1 percent of total annual GHG emissions for the entire San Francisco Bay Area.[7] If amortized over the 30-year lifespan for the project, these one-time emissions represent an even smaller fraction of San Francisco Bay Area emissions.

In addition, best management practices (BMPs) to reduce GHG emissions would be implemented, when it is feasible and applicable. BMPs could include, but are not limited to: adhering to BAAQMD idling regulations for diesel, composting of removed vegetation on-site, ensuring that equipment is properly maintained, providing that at least 15 percent of the operational fleet be comprised of alternatively fueled (e.g., biodiesel, electric) vehicles and equipment, using at least 10 percent local building materials, or recycling or reusing at least 50 percent of waste or demolition materials.

[7] BAAQMD reported regional Bay Area GHG emissions in 2007 at approximately 95.8 MMTCO2e (88.7 MMTCO2e were emitted within the San Francisco Bay Area Air District and 7.1 MMTCO2e were indirect emissions from imported electricity).

With the small anticipated emissions from equipment operations and the implementation of BMP to minimize these emissions, this impact would be less than significant.

**Table 4.6-3**
**Estimated GHG Emissions During Vegetation Removal Activities**

| Years: 2012-2013 | $CO_2$ |
|---|---|
| 2012 Emissions | 3.9 |
| 2013 Emissions | 1.8 |
| **Total $CO_2e$ (Metric Tons)** | **5.7** |
| Notes: GHG = greenhouse gas | |

**Impact GHG-4: Project implementation would not conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing GHG emissions. (Less than Significant)**

As discussed above under Impact GHG-1, the project's GHG emissions would not exceed the adopted BAAQMD GHG significance thresholds. Given that only small operational GHG emissions will be emitted as a result of the proposed project, the proposed project would not conflict with the State's AB 32 goal and associated scoping plan estimates of reducing GHG emissions to 1990 levels by 2020.

The proposed project would increase the activity onsite due to activities related to vegetation management but would comply with state and regional GHG plans. No long-term GHG emissions would occur after completion of vegetation management activities. For these reasons, the project would result in a ***less than significant*** impact with respect to GHG emissions during project implementation.

## Cumulative Impacts

The GHG impacts of the proposed project, as described above are the short-term reduction of 11,286 tons of CO2e (10,239 metric tons) of the Reserve's above-ground carbon sink and an increase of 5.7 metric tons of CO2e during the implementation of the project. These impacts, along with similar impacts in the region resulting from other projects, contribute to cumulative GHG impacts.

Other projects in the San Francisco area were reviewed to assess whether the contributions of impacts from the proposed project would result in a significant impact on GHG emissions or carbon sequestration. Recently released environmental documents list a number of projects in the San Francisco area, including projects from National Park Service, Golden Gate National Recreation Area, San Francisco Planning Department, San Francisco Redevelopment Agency, San Francisco Recreation and Park Department, San Francisco Public Works Department, Port of San Francisco, and San Francisco County Transportation Authority (AECOM 2012, SFCTA 2011). Project listed in these documents were reviewed to assess cumulative impacts.

**Impact GHG-5: The proposed vegetation management activities would contribute to cumulative impacts, but not at levels that would result in a significant impact on the environment. (Less than Significant)**

As described above, the proposed vegetation management activities would result in a less than significant, short-term reduction in the Reserve's carbon sink. In addition, implementation of the project would result in a less than significant contribution to GHG emissions.

No other similar large vegetation removal projects in San Francisco were identified. All projects reviewed consisted of infrastructure development (e.g., road and bike lane improvements, housing, hospital facilities).The majority of other on-going and proposed projects would occur in developed areas of the city, and as such, would have limited impacts on vegetation and carbon storage. There is potential for minor reductions in carbon storage associated with other development projects, some of which may be replaced through planted landscaping. With the limited impacts to carbon storage associated with other nearby projects and the less than significant impacts of the proposed project, the cumulative impact of the proposed project from vegetation management activities would also be less than significant.

The construction of other San Francisco projects would contribute to GHG emissions through the operation of construction vehicles and equipment. Many of the projects proposed in San Francisco are routine operations necessary to maintain infrastructure, and as such contribute to background level of emissions in the City. The contributions the proposed project's implementation emissions are negligible in comparison to this background. The minor contribution of emissions contributed by the proposed project in combination with emissions from other local projects would be less than significant.

Overall, contributions of the proposed project to cumulative GHG impacts would be less than significant.

## 4.6.7 REFERENCES

AECOM. 2012. Draft Environmental Impact Statement (EIS). San Francisco Veterans Affairs Medical Center (SFVAMC), Long Range Development Plan (LRDP). August 17.

Bay Area Air Quality Management District (BAAQMD). 2012. Bay Area Air Quality Management District updated CEQA guidelines. Accessible here: http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Updated-CEQA-Guidelines.aspx

Borough, D. J., W. D. Incoll, J. R. May, and T. Bird. 1978. Chapter 10. Yield statistics. p. 201-225. *In* Eucalypts for wood production. W. E. Hillis and A. G. Brown, eds. Commonwealth Scientific and Industrial Research Organization, Canberra, Australia.

Bosquet, P., P. Peylin, P. Ciais, C. L. Quere, P. Friedlingstein, and P. P. Tans. 2000. Regional changes in carbon dioxide fluxes of land and oceans since 1980. Science 290:1342–1346.

California Air Resources Board (CARB). 2008 *Climate Change Proposed Scoping Plan: a framework for change*. October.

California Board of Forestry and Fire Protection. 2008. *Draft Report to ARB on Meeting AB 32 Targets.* August 20.

California Environmental Protection Agency. 2006. *Climate Action Team Report to Governor Schwarzenegger and the Legislature*. March.

EPA (Environmental Protection Agency). 2012a. Sources of Pollutants in the Ambient Air - Stationary Sources. Accessed at: http://www.epa.gov/apti/course422/ap3b.html

EPA (Environmental Protection Agency). 2012b. Direct Emissions from Mobile Construction Sources. Accessed at: http://www.epa.gov/climateleadership/documents/resources/mobilesource_guidance.pdf

FAO (Food and Agriculture Organization of the United Nations). 1979. Eucalypts for planting. FAO Forestry Series 11. Rome, Italy. 677 p.

HortScience. 1999. Tree survey: Mount Sutro Open Space Reserve maintenance and restoration plan.

IPCC. 2007. Intergovernmental Panel on Climate Change: Fourth Assessment Report. Accessible here: http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

J.A. Rinehart, R.B. Standiford. 1983. Growth and yield in Eucalyptus globulus. USDA- Forest Service Gen. Tech. Rep. PSW 69. Berkeley, CA. pgs 61-68.

Jenkins, J.C., Chojnacky, D.C., Heath, L.S., and Birdsey, R.A. 2003. National-scale biomass estimators for US tree species. Forest Science 49 (1).

Kimmons, J.P. 1997. A foundation for forest management. Forest Ecology. Second edition. Prentice Hall.

Krumland, B.E. and L.E. Wensel. 1975. Preliminary young growth volume tables for coastal California conifers. Research Note #1. In-house memo. Co-op Redwood Yield Research Project. Department of Forestry and Conservation, College of Natural Resources, U. of Cal, Berkeley. On file with the PNW Research Station. (see Table 1, page 4).

McClatchie, A.J. 1902. Eucalypts cultivated in the United States. USDA- Bureau of Forestry. Bulletin No. 35. 103 pgs.

Pillsbury, N. and Kirkley, M. L. 1984. Equations for total, wood, and saw-log volume for thirteen California hardwoods. Res. Note PNW-414. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 52 pp.

Pillsbury, N. and Reimer, J. L. 1997. Tree volume equations for 10 urban species in California. USFS Forest Service Gen. Tech. Rep. PSW-GTR-160. 465-478.

SFCTA (San Francisco County Transportation Authority). 2011. Draft Environmental Impact Statement/Environmental Impact Report Van Ness Avenue Bus Rapid Transit Project. October.

Shaw, R., D. Cameron, B. Morris, G. Bratman, D. Bachelet, K. Klausmeyer, J MacKenzie, D. Conklin, J. Lenihan, E. Haunreiter, and C. Daly. 2009. The impact of climate change on California's ecosystem services. California Energy Commission, PIER Research Report, CEC-500-2009-025. Available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-025/CEC-500-2009-025-F.PDF. Website accessed 5/3/2012.

University of California San Francisco (UCSF). 2010. Notice of Preparation/ Initial Study for EIR. December 10, 2010. Accessible at: http://campusplanning.ucsf.edu/pdf/Initial_Study_UCSF_Mt_Sutro_Mgmt.pdf

USFS. 2009. Biomass equations for California, Washington and Oregon. USDA Forest Service, Washington D.C. Accessible here: http://www.climateactionreserve.org/how/protocols/adopted/forest/resources/#biomass-equations.

Wayburn, L., Franklin, J.F., Gordon, J. C., Binkley, C. S., Mladenoff, D. J., Christensen, N. L., Jr. 2000. Forest carbon in the United States. Pacific Forests 3(2): 44 pgs.

**Personal communication**

Personal communication between Avanti Tamhane, URS Senior Scientist, Letty Brown, URS Senior Forester, and Alison Kirk, Senior Environmental Planner, Bay Area Air Quality Management District. Email and phone calls on 7.30 and 7.31.2012.

Personal communication with Julie Sutton (via Diane Wong). Email correspondence on August 3, 2012 between Julie Sutton, Supervisor Landscaping and Grounds at UCSF, and Dr. Brown, Senior Forester at URS Corp (via Diane Wong, Senior Planner and Environmental Coordinator at UCSF).

# 4.7 HAZARDS -- FIRE HAZARDS

## 4.7.1 INTRODUCTION

This section discusses the potential impacts of the proposed project in regard to fire hazards associated with proposed management activities. The impacts associated with the proposed project are compared with the thresholds of significance adopted pursuant to CEQA.

Comments related to fire hazards received during the Initial Study/EIR scoping process included concerns about the following:

- A potential increase in the wildfire hazard by removing vegetation that retains moisture
- A potential increase in the spread of wildfire by reducing the windbreak formed by the dense forest and by altering wind patterns

Other commenters expressed a desire to proceed with the proposed project to address the existing fire hazard.

## 4.7.2 ENVIRONMENTAL SETTING

### Fire Hazard

Eucalyptus globulus, or Tasmanian blue gum, was first introduced to the San Francisco Bay region in 1853 as an ornamental landscaping tree. Soon after, it was widely planted for timber production when domestic lumber sources were being depleted. During the last three decades of the 19th century, large areas of San Francisco were planted with trees on what had previously been sand dunes or unforested hillsides, mostly as a means of aesthetic improvement to the natural landscape, which was perceived as barren. The trees at the Presidio of San Francisco, Golden Gate Park, Stern Grove and Mount Sutro are examples of these late 19th century, large scale tree-planting efforts of which portions continue to survive today.

The blue gum continues to be the most widespread species of eucalyptus found in California. As discussed in the Project Description, the Reserve is dominated (82%) by blue gum eucalyptus, planted in the late 1800s. Other tree species include Monterey pine, Monterey cypress, blackwood acacia, and coast redwood. The understory is thick with Himalayan blackberry, and other non-native and native shrubs and vines. According to the UCSF Mount Sutro Open Space Reserve Management Plan, the regeneration and spread of blue gum eucalyptus has been prolific because the trees are very adaptable to the conditions of the site, they re-sprout vigorously, and they suppress the growth of other plant species. The oils in the foliage and bark inhibit the seed

germination and early plant growth of many other plants. The annual shedding of bark is one of the main reasons the trees present a significant fire hazard.[1]

The Mount Sutro Open Space Reserve Management Plan indicates that, as with any monocultural (i.e. single species) forest, the trees of the Reserve are particularly prone to widespread disease and wildfire.[2] Their vulnerability will increase as more trees become stressed from greater competition with one another and as more die. The denser and more stressed the trees become, the more they are susceptible to infestation by pests.

In addition, wildfire spreads more rapidly in a diseased forest than a healthy one. Compared to redwood, cypress, coast live oak, and most other tree species, eucalyptus are considered more hazardous because their oils are conducive to fire ignition, their curly strips of lightweight bark and leaves can carry sparks considerable distances (i.e. miles), and they create excessive debris (i.e. fuel load) on the forest floor.[3] In addition, denser forests (such as the Reserve) burn more quickly and intensely than one where trees are more spread out. Vines on tree trunks act as "fuel ladders," and can send a ground-level wildfire up into the tree canopy where it spreads more rapidly. French broom, another invasive shrub found in the Reserve, is also considered to be a high fire hazard species.

A report on the condition of the Reserve was prepared in 1999 by HortScience.[4] At that time, HortScience determined that the general condition of the Reserve's trees is only fair to good, but the prevalent small trees throughout the forest are generally in worse condition than the large trees that dominate the forest canopy. The overall condition of eucalyptus saplings was assessed as poor, and most of the standing dead trees observed by HortScience were less than six inches in diameter. The regeneration and recruitment of eucalyptus into the forest canopy is limited, and little regeneration is occurring even when trees fall and create gaps in the canopy. The rampant growth of English ivy, Himalayan blackberry and other invasive exotic species further impedes regeneration. According to HortScience, without healthy regeneration through proactive management, the forest will continue to decline, and may eventually be overtaken by the invasive understory of shrubs and ivies.[5]

Since preparation of the HortScience report, arborists retained by UCSF have observed that conditions in the Reserve have deteriorated (see Figures 4.7-1 to 4.7-3). More trees are in decline, sapling health remains poor, and fuel loads have increased. Trees within a portion of the South Ridge area of the Reserve are currently suffering from an infestation of the snout beetle, which may ultimately cause the trees to die.

---

[1] National Park Service, U.S. Department of the Interior, Golden Gate National Recreation Area, Point Reyes National Seashore, *Eucalyptus* Newsletter, printed 2006. http://www.nps.gov/goga/parkmgmt/fire_edu_newsletter_eucalyptus.htm

[2] UCSF Mount Sutro Open Space Reserve Management Plan, September 2001, p. 21.

[3] Ibid, p. 22.

[4] UCSF Mount Sutro Open Space Reserve Maintenance and Restoration Plan, July 1999, prepared by HortScience

[5] UCSF Mount Sutro Open Space Reserve Management Plan, September 2001, p. 21.

Source: UCSF

**Figure 4.7-1**
West side of the Reserve looking west

Source: UCSF

**Figure 4.7-2**
West side of the Reserve looking northwest

Source: UCSF

**Figure 4.7-3**
Sparse tree canopies

The primary vegetation issues at the Reserve are:

- Young trees complete for sunlight and nutrients and are dying throughout the forest
- English ivy on tree trunks overloads and shades out trees, especially mature ones.
- Heavy accumulation of forest debris is fuel for wildfires.
- Hazardous leaning trees and heavy lateral branches could fall.

Mount Sutro is within three miles of the Pacific Ocean and has a coastal climate with seasonally varied precipitation in the form of both rain and fog. Rainfall is concentrated in the October – May period. While fog may be present much of the year, particularly during summer months, dry conditions with above-normal temperatures typically occur in late summer and early fall, approximately September – November. Commonly during this period, the semi-permanent low pressure system of the southwestern United States weakens and the Pacific high pressure system shifts inland, allowing hot, dry, high-intensity winds to blow in from the northeast. These winds, in combination with unusually high air temperatures, low humidity and dry vegetation increase the vulnerability of the Reserve to wildfire for several weeks in the autumn.

Nearby properties that could be threatened by a potential wildfire in the Reserve include the facilities on the UCSF campus, including the Aldea Housing complex, the Chancellor's

Residence, and structures on the densely-developed campus shelf: Moffitt and Long Hospitals, the campus central utilities plant, and premier research and teaching facilities in buildings such as the Regeneration Medicine Building, Health Sciences East and West buildings, Medical Sciences Building, and the Vision Research Building, among others. In addition, a wildfire in the Reserve could threaten private residences in close proximity to the Reserve. Many are directly adjacent to the Reserve along Edgewood Avenue, Clarendon Avenue, and Crestmont and Christopher Drives. Embers that are carried by wind could spark fires in nearby neighborhoods that surround the Reserve, which are predominantly residential.

## Fire History

On October 8, 1899, 60 acres of Mount Sutro were destroyed by a fire event (the "great Sutro fire"), and threatened the Affiliated Colleges (which later became UCSF) on the north side of the mountain and the Alms House (later Laguna Honda Hospital) on the south side. Sutro's papers note that small fires occurred frequently thereafter during the summer.[6]

At least three more recent fires in the Reserve have been documented, and each was discovered quickly and extinguished.[7] The most recent one occurred in 1999 and was started by a campfire that UCSF staff spotted soon after it began to spread. The UCSF Campus Fire Marshal and others expressed concern about the potential for a large wildfire, particularly in the fall when the forest is driest. In the event of a wildfire in the Reserve, which would likely go immediately to a second-alarm fire according to the San Francisco Fire Department (SFFD), both Station 12 (on Stanyan Street near Parnassus Avenues) and Station 20 (on Olympia Way near Clarendon Avenue) would respond.[8] If it increased to a third-alarm fire, Station 5 (at Turk and Webster Streets) would also respond.

Throughout the San Francisco Bay Area, fire risks and management challenges are posed in forested areas and on lands with expansive vegetation. The most notable wildfires in recent times are the East Bay Hills Tunnel Fire (a.k.a. the Oakland Hills Fire or the Oakland Firestorm), which occurred in October 1991 and killed 25 people; and the wildfire on Angel Island which occurred in October 2008 and burned about 300 acres, about forty percent of the island's total area. According to an Angel Island State Park Superintendent, firefighting activities on Angel Island were helped immeasurably by prior vegetation management and fuel reduction efforts that took place on the island, including removal or thinning of the island's eucalyptus and pine trees.[9] The Presidio, Golden Gate Park, and East Bay Hills have substantial eucalyptus, Monterey cypress, and Monterey pine forests that were planted in the late 1800s and are susceptible to wildfire. Plans for the management of these areas to ensure their long-term health and safety have been adopted by the agencies with jurisdiction over these resources.

---

[6] Richard Brandi, *Farms, Fire and Forest: Adolph Sutro and Development "West of Twin Peaks"*, published in The Argonaut, Journal of the San Francisco Museum and Historical Society, Volume 14 No. 1, Summer 2003, p. 40

[7] UCSF Mount Sutro Open Space Reserve Management Plan, September 2001, p. 22, and FEMA Grant Application for the UCSF Mount Sutro South Ridge Vegetation Management Project, p. 14.

[8] UCSF Mount Sutro Open Space Reserve Management Plan, September 2001, p. 22

[9] *East Bay Regional Parks District Wildfire Hazard Reduction and Resource Management Plan*, July 2009, p. 9.

## 4.7.3 FEDERAL, STATE, REGIONAL, AND LOCAL PLANS AND GUIDANCE

Fire management in the Bay Area falls within the jurisdiction of many agencies and is informed by federal, state, regional, and local regulations, plans and by published guidance. While the University is not under the jurisdiction of the agencies discussed below, information on the plans identified is provided to establish the context for fire management in the region

### National Park Service

The National Park Service (NPS), part of the United States Department of the Interior, in recognition of the vast eucalyptus plantings within the Golden Gate National Recreation Area (GGNRA), developed a brochure on how to manage eucalyptus.[10] The brochure discusses the high flammability of eucalyptus, as well as the unique challenges in managing eucalyptus forests and minimizing their fire hazards. The NPS suggests a variety of ways in which fire hazards caused by eucalyptus may be reduced. These include removing understory; thinning tree stands by removing select trees and leaving remaining trees evenly spaced; and completely removing tree stands.

The project site is not within the GGNRA or under the jurisdiction of the NPS. However, the main management actions proposed by UCSF as part of the proposed project -- thinning of tree stands and removal of understory – are consistent with the guidance provided in the NPS brochure.

### California Department of Forestry and Fire Protection

The California Department of Forestry and Fire Protection (CAL FIRE) is dedicated to the fire protection and stewardship of millions of acres of California's wildlands within State Responsibility Areas (SRA).[11] In addition, the Department provides varied emergency services in many of the State's counties via contracts with local governments. The Department's firefighters, fire engines, and aircraft respond to an average of more than 5,600 wildland fires each year. Those fires burn more than 172,000 acres annually. CAL FIRE's mission emphasizes the management and protection of California's natural resources; a goal that is accomplished through ongoing assessment and study of the State's natural resources and an extensive CAL FIRE Resource Management Program.[12]

---

[10] National Park Service, US Department of the Interior, *Managing Eucalyptus*, September 2006, http://www.nps.gov/goga/parkmgmt/upload/firemanagement_eucalyptus_brochure.pdf

[11] A State Responsibility Areas (SRA) is a geographic area where the state has financial responsibility for fire protection. San Francisco County does not contain any SRAs.

[12] California Department of Forestry and Fires Protection website, http://www.fire.ca.gov/about/about.php, accessed June 2012.

The California Fire Plan is produced and periodically updated by CAL FIRE. The most recent plan, *2010 Strategic Fire Plan for California*, was the first produced in collaboration with the State Board of Forestry and Fire Protection. The plan seeks to reduce the risk of wildfires, reduce fire-fighting costs and property losses, increase firefighter safety, and contribute to ecosystem health. One of the major policy components is "fuel hazard reduction that creates resilient landscapes and protects the wildland and natural resource values."[13]

CAL FIRE's Fire and Resource Assessment Program (FRAP) developed Fire Hazard Severity Zoning maps for all of California, ranking areas as Very High, High or Moderate fire hazard severity. Based on a screening level analysis that was prepared for all of California, the map for San Francisco indicates that the Mount Sutro area is within a "Moderate" fire hazard zone. The CAL FIRE website indicates that the map is still draft and may not be current.[14] CALFIRE has prepared a more refined analysis for those communities falling within a SRA. However, as San Francisco County does not contain any SRAs, CALFIRE has not prepared a more refined analysis of fire hazard severity in San Francisco. That responsibility falls to the City and County of San Francisco (see San Francisco Hazard Mitigation Plan, below).

## California Multi-Hazard Mitigation Plan

As a state facility, the UCSF campus is covered by the California Multi-Hazard Mitigation Plan, also known as the State Hazard Mitigation Plan (SHMP).[15] Prepared by the California Emergency Management Agency (Cal EMA), the SHMP's purpose is to significantly reduce deaths, injuries, and other disaster losses caused by natural and human-caused hazards in California. California's disaster history since 1950 indicates that the primary hazards of earthquakes, floods, and wildfires require priority attention because they account for the largest losses.[16] The SHMP states that among the three primary hazards, wildfire and particularly wildland-urban interface (WUI)[17] fire represents the third most destructive source of hazard, vulnerability, and risk.[18] The SHMP discusses, among other things, the history of WUI fire, and recognizes urban conflagrations, or large disastrous fires in an urban area, as a major hazard that can occur due to many causes such as wildfires, earthquakes, gas leaks, or arson.

---

[13] California Department of Forestry and Fire Protection, *2010 Strategic Fire Plan for California*, p. 2. http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan

[14] California Department of Forestry and Fire Protection, Fire Maps: http://frap.cdf.ca.gov/data/frapgismaps/select.asp?theme=5 http://frap.cdf.ca.gov/webdata/maps/san_francisco/fhsz_map.38.jpg

[15] Hazard mitigation, as defined in Title 44 Code of Federal Regulations (CFR), Subpart M, Section 206.401, is "any action taken to reduce or eliminate the long-term risk to human life and property from natural hazards." In California, the Governor's Office of Emergency Services (OES) has expanded this definition to include human-caused hazards. As such, hazard mitigation is any work done to minimize the impacts of any type of hazard event before it occurs. It aims to reduce losses from future disasters.

[16] State of California Multi-Hazard Mitigation Plan, October 2010, p. 31. http://hazardmitigation.calema.ca.gov/docs/2010_SHMP_Final.pdf

[17] The wildland-urban interface, or "WUI," is an area where structures and other human development meets or intermingles with wildland or vegetative fuels.

[18] State of California Multi-Hazard Mitigation Plan, October 2010, p. 233. http://hazardmitigation.calema.ca.gov/docs/2010_SHMP_Final.pdf

The SHMP indicates that managing the human/wildfire conflict requires a commitment of resources and a focused mitigation plan over the long term. It states that the approach must include the following:

- An informed, educated public that takes responsibility for its own decisions relating to wildfire protection
- An effective wildfire suppression program
- An aggressive hazardous fuels management program
- Land use policies and standards that protect life, property and natural resources
- Building and fire codes that reduce structural ignitions from windblown embers and flame contact from wildland-urban interface fires and impede or halt fire spread within the structure once ignited
- Construction and property standards that provide defensible space

The proposed project would be consistent with "hazardous fuels management" identified above.

## Association of Bay Area Governments

The Association of Bay Area Governments (ABAG) developed the *Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area*, which focuses on describing the most significant natural hazards affecting the San Francisco Bay Area related to earthquakes and weather (wildfire, flooding, and landslides). The original plan was adopted in 2005.[19] An update was adopted in 2010, which, in addition to the natural hazards assessed in the 2005 report, included considerations of drought, climate change and tsunamis, as well as dam failure, and levee failure.[20]

The 2005 plan identified the significant risk posed by wildfire and notes the particular hazard contribution from non-native species such as eucalyptus or pine trees.[21] The plan recommended vegetation management programs including the reduction of fuel loads and use of defensible space. The ABAG Plan also includes fire hazard maps, including a Wildland Urban Interface – Fire Threatened Communities map, which indicates that Mt. Sutro and the surrounding area, as well as other neighborhoods adjacent to forested areas such as the Presidio and Golden Gate Park, is a "Community at Risk".[22]

---

[19] Association of Bay Area Governments, *Taming Natural Disasters, Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area,* March 17, 2005, http://www.abag.ca.gov/bayarea/eqmaps/mitigation/ThePlan-Version-Mar05.pdf

[20] Association of Bay Area Governments, *Taming Natural Disasters, Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area,* 2010 Update of the 2005 Plan, http://quake.abag.ca.gov/wp-content/documents/ThePlan-Chapters-Intro.pdf

[21] Association of Bay Area Governments, 2005 Plan, op.cit., p. 7.

[22] Association of Bay Area Governments, 2005 Plan, Map Plates, Plate 47, http://quake.abag.ca.gov/wp-content/documents/Map-Plates.pdf

## San Francisco Hazard Mitigation Plan

The City and County of San Francisco, led by the San Francisco Department of Emergency Management, developed their Hazard Mitigation Plan (HMP)[23] to assess risks posed by natural and human-caused hazards and to develop a mitigation strategy for reducing the City's risks. The City prepared the HMP in accordance with the requirements of the Disaster Mitigation Act of 2000, enabling the City to receive reimbursement from the Federal Emergency Management Agency (FEMA) for qualifying expenses in the event of a major disaster.

The HMP determined that seismic hazards as well as weather-related hazards, including wildfire, are among the hazards that pose the greatest threat to San Francisco.[24] The following discussion on wildfire in San Francisco is excerpted from the HMP, p. 5-18:

> *The following three factors contribute significantly to wildfire behavior and can be used to identify wildfire hazard areas.*
>
> - ***Topography:*** *As slope increases, the rate of wildfire spread increases. South-facing slopes are also subject to more solar radiation, making them drier and thereby intensifying wildfire behavior. However, ridgetops may mark the end of wildfire spread, as fire spreads more slowly or may even be unable to spread downhill.*
> - ***Fuel:*** *The type and condition of vegetation plays a significant role in the occurrence and spread of wildfires. Certain types of plants are more susceptible to burning or will burn with greater intensity; and nonnative plants may be more susceptible to burning than native species. Dense or overgrown vegetation increases the amount of combustible material available to fuel the fire (referred to as the "fuel load"). The ratio of living to dead plant matter is also important. The risk of fire increases significantly during periods of prolonged drought, as the moisture content of both living and dead plant matter decreases; or when a disease or infestation has caused widespread damage. The fuel's continuity, both horizontally and vertically, is also an important factor.*
> - ***Weather:*** *The most variable factor affecting the behavior of wildfires is weather. Temperature, humidity, wind, and lightning can affect chances for ignition and spread of fire. Extreme weather, such as high temperatures and low humidity, can lead to extreme wildfire activity. By contrast, cooling and higher humidity often signal reduced wildfire occurrence and easier containment.*
>
> *Even small fires can threaten lives and resources and destroy improved properties. If not promptly controlled, wildfires may grow into an emergency or disaster.*

As discussed above, CALFIRE has not prepared a refined analysis to identify the wildfire hazard severity in San Francisco, only a screening level analysis. A refined analysis to determine the wildfire hazard severity was conducted for the San Francisco HMP. Using CALFIRE's fuel ranking assessment methodology, and based on more detailed data available for San Francisco, the HMP determined that wildfire hazard severity for Mount Sutro is High and Very High.[25]

---

[23] City and County of San Francisco, *2008 City and County of San Francisco Hazard Mitigation Plan*, December 2008 http://www.sfdem.org/ftp/uploadedfiles/DEM/PlansReports/HazardMitigationPlan.pdf

[24] Ibid, p. 5-4.

[25] Ibid, Appendix C, Wildfire Hazard Area, p. C-13.

Other areas in San Francisco containing dense vegetation such as in Golden Gate Park, the Presidio, and Stern Grove, also ranked High and Very High.

The HMP identifies potential mitigation actions in Table 8-2 (p. 8-6), including action 4.J.:

> *Implement a fuel reduction program, such as the collection and disposal of dead fuel, within parks and open space.*

### City of San Francisco General Plan: Community Safety Element

The *San Francisco General Plan* contains comprehensive objectives and policies that guide land use and land use-related matters in the City. Although the University is constitutionally exempt from regulation by local agencies when using its properties to further its educational mission, the University strives to be consistent with local policies where feasible.

The manner in which the General Plan goals are to be attained is set forth through a statement of objectives and policies in a series of elements, which apply citywide, with each element dealing with a particular topic. The General Plan contains the following elements: Housing, Commerce and Industry, Recreation and Open Space, Community Facilities, Transportation, Community Safety, Air Quality, Environmental Protection, Urban Design and Arts.

The purpose of the Community Safety Element (Element) is to facilitate community resilience and reduce future loss of life, injuries, property loss, environmental damage, and social and economic disruption from natural or technological disasters. The Element establishes policies to guide the City's actions in preparation for, response to, and recovery from a major disaster. Implementation of the Element is carried out through a number of City plans and programs, most specifically the City's Hazard Mitigation Plan (described above), as well as by various agencies referenced in the Element's policies. The Community Safety Element focuses on seismic hazards, because according to the Element the greatest risks to life and property in San Francisco result directly from the ground shaking, ground failure, and other impacts associated with large earthquakes. Therefore, the objectives and policies of the Community Safety Element are not specific as to wildfire, but relate to seismic events or more broadly relate to emergency preparedness, response, and recovery in general. The proposed project would not conflict with objectives or policies of the Community Safety Element.

## 4.7.4 SIGNIFICANCE STANDARDS AND METHODOLOGY

### Significance Criteria

According to the Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment if it would:

- Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan

- Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands

### Issues Not Discussed Further

As discussed in the NOP/Initial Study for the UCSF Mount Sutro Management Project, proposed management activities would not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan. Access roads around and through the Reserve would remain unchanged with the proposed project. With proposed new trail segments, pedestrian access would be improved. Therefore, the proposed project would have no impact emergency response or emergency evacuation, and this topic will not be analyzed in the EIR.

## 4.7.5 IMPACTS AND MITIGATION MEASURES

**Impact FIRE-1: The project could expose people or structures to a significant risk of loss, injury or death involving wildland fires. (Significant; Less than Significant with Mitigation)**

The express purpose of the proposed project is to improve the health of the forest and to reduce the exposure of persons and property to a wildfire. The range of proposed management activities, which include thinning of the forest, removal of much of the understory, and native plantings in select areas, are intended to reduce the amount of easily combustible vegetation (i.e. fuel load) to reduce the risk of wildfire. Fuel load reduction includes the removal of dead, dying, and unhealthy vegetation and trees. Thinning of the forest would increase the amount of open space between trees, reducing the ability of fire to rapidly spread.

Proposed management activities were identified with the assistance of forestry professionals with extensive experience in forest and wildfire management. The same management approaches proposed by the project are commonly and successfully employed elsewhere in the San Francisco Bay Area. Agencies with responsibility for wildfire management in the San Francisco Bay Area have recommended fuel load reduction as a means to inhibit and control wildfires. These agencies include those named above in Section 4.1.3: The U.S. Department of the Interior, National Park Service; the California Department of Forestry and Fire Protection (CAL FIRE); the California Emergency Management Agency (CAL EMA); and the San Francisco Department of Emergency Management.

While concerned persons have asserted that the proposed management activities may actually increase fire risk compared to current conditions, there is no evidence to suggest that to be the case. Project opponents contend that removal of the understory and some trees would reduce the material that captures fog drip, retains moisture, and reduces the risk of fire ignition. However, as indicated previously, the period of greatest concern for risk of fire is during the dry months in late summer through early autumn, on those days when fog is not prevalent and high

temperatures and wind conditions provide a heightened risk for fire. It is during these times that the vegetation is most dry. Although this period is limited, the risk is present nonetheless.

Forest thinning and understory removal activities have occurred at the Presidio in San Francisco, Angel Island, and in numerous other parks and open spaces throughout the Bay Area, without an increase in fire incidence. The completed management activities in these areas have been credited with improved health and appearance of the forest. For example, at Angel Island, the fuel management activities that occurred prior to the 2008 wildfire were credited as having helped with fire-fighting efforts. In addition, there is no evidence that these prior fuel management activities contributed to the cause or extent of the wildfire.

Concerned persons have also indicated that forest-thinning activities would alter the windbreak, and change wind patterns in a manner that would increase the risk for wildfire spread. As indicated in Section 4.11 Wind, proposed forest thinning activities have the potential to increase wind speeds in adjacent neighborhoods, but the effect would be very limited and not significant (see Section 4.11.5). Forest thinning activities would allow increased wind penetration within the Reserve. Wind speed effects and the spread of wildfire within the Reserve would depend on a number of factors that include the location of the fire, wind speed direction, wind velocity at the time of the fire, topography, and available fuel. There is no evidence to suggest that wind patterns would be altered in such a way as to increase the spread of wildfire, compared to the spread of wildfire under existing conditions with widespread fuel loads. As the reduction in fuel proposed by the project would limit the spread of fire, this impact is less than significant.

The use of heavy equipment, chainsaws and other motorized devices could increase the risk of fire during implementation of management activities. **Mitigation Measure FIRE-1**, includes measures to reduce the risk to less-than-significant levels. With the implementation of this mitigation measure, the proposed project would not expose persons or property to an increased risk of loss, injury, or death due to wildfire. Therefore, impacts with regard to this topic would be less than significant.

**Mitigation Measure FIRE-1**: To reduce the risk of fire ignition and the spread of fire while implementing management activities, the following measures shall be taken:

- Earthmoving and portable equipment with internal combustion engines shall be equipped with a spark arrestor to reduce the potential for igniting a wildland fire (Public Resources Code Section 4442)
- Appropriate fire suppression equipment shall be maintained in the vicinity of management activities during the highest fire danger period – from April 1 to December 1 (Public Resources Code Section 4428)
- Workers shall carry fire extinguishers in their trucks and use appropriate fire prevention and suppression measures while undertaking management activities
- No treatment actions involving motorized equipment shall take place during Red Flag warnings in San Francisco, unless the San Francisco Fire Department specifies precautions to allow their use

**Significance after Mitigation:** Less than Significant

**Impact FIRE-2: Effects of cumulative management activities could increase the risk of exposure to wildland fire. (Less than Significant)**

As part of the San Francisco Significant Natural Resource Areas Management Plan (SNRAMP), the City of San Francisco proposes to conduct vegetation management activities, including the select removal of invasive plants and trees such as eucalyptus, within the Interior Greenbelt area directly adjacent to the Reserve. For the same reasons that an increased fire risk would not occur with the proposed project, no increased fire risk would occur with the SNRAMP project. Wildfire risk would not increase as a result of the cumulative effect of these two projects. Rather, a reduction in fuel load and improved forest health in both the Reserve and Interior Greenbelt would be cumulatively beneficial with regard to exposure to wildfire. Therefore, the proposed project would result in a less-than-significant cumulative impact.

**Mitigation:** None required.

## 4.7.6 REFERENCES

Association of Bay Area Governments, *Taming Natural Disasters, Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area,* March 17, 2005, http://www.abag.ca.gov/bayarea/eqmaps/mitigation/ThePlan-Version-Mar05.pdf

Association of BayArea Governments, *Taming Natural Disasters, Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area,* 2010 Update of the 2005 Plan, http://quake.abag.ca.gov/wp-content/documents/ThePlan-Chapters-Intro.pdf

Richard Brandi, *Farms, Fire and Forest: Adolph Sutro and Development "West of Twin Peaks"*, published in The Argonaut, Journal of the San Francisco Museum and Historical Society, Volume 14 No. 1, Summer 2003

California Department of Forestry and Fires Protection website, http://www.fire.ca.gov/about/about.php

California Department of Forestry and Fire Protection, *2010 Strategic Fire Plan for California*, http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan

California Department of Forestry and Fire Protection, Fire Maps:
http://frap.cdf.ca.gov/data/frapgismaps/select.asp?theme=5
http://frap.cdf.ca.gov/webdata/maps/san_francisco/fhsz_map.38.jpg

California Multi-Hazard Mitigation Plan, October 2010
http://hazardmitigation.calema.ca.gov/docs/2010_SHMP_Final.pdf

City and County of San Francisco, *2008 City and County of San Francisco Hazard Mitigation Plan*, December 2008 http://www.sfdem.org/ftp/uploadedfiles/DEM/PlansReports/HazardMitigationPlan.pdf

East Bay Regional Parks District, *East Bay Regional Parks District Wildfire Hazard Reduction and Resource Management Plan*, July 2009

National Park Service, U.S. Department of the Interior, Golden Gate National Recreation Area, Point Reyes National Seashore, *Eucalyptus* Newsletter, printed 2006. http://www.nps.gov/goga/parkmgmt/fire_edu_newsletter_eucalyptus.htm

National Park Service, US Department of the Interior, *Managing Eucalyptus*, September 2006, http://www.nps.gov/goga/parkmgmt/upload/firemanagement_eucalyptus_brochure.pdf

# 4.8 HAZARDS -- HERBICIDE USE

## 4.8.1 INTRODUCTION

This section discusses the potential impacts of the proposed project in regard to herbicide use during implementation of proposed management activities. The analysis was prepared by Leonard Charles & Associates in conjunction with Pesticide Research Institute. The background report prepared by Pesticide Research Institute, *University of California, San Francisco, Herbicide Risk Assessment,* April 2012, is included in Appendix G of this EIR.

While UCSF has committed to exploring various options for vegetation regrowth control, the use of herbicides cannot be ruled out and is therefore analyzed in this section. Currently, herbicides are not in use in the Reserve. The proposed Demonstration projects are designed, in part, to test the efficacy of herbicide use on controlling vegetation regrowth in the Reserve. Based on the results of the Demonstration projects, information contained in this EIR, and any other sources of information deemed appropriate, the University would develop a policy regarding herbicide use in the Reserve. While a policy regarding herbicide use will not be developed until completion of the Demonstration projects, the analysis of project impacts contained in this chapter assumes, to assess worst-case conditions, that herbicides would be used in the Reserve as part of the Demonstration projects, for continued vegetation management in the remainder of the Reserve, and for ongoing maintenance. The impacts associated with the proposed project are compared with the thresholds of significance adopted by the California Environmental Quality Act (CEQA).

Comments related to herbicide use received during the Initial Study/EIR scoping process included concerns about the following:

- Dangers to persons and wildlife
- The spread of herbicides to adjacent properties
- The use of Roundup and/or Garlon
- Impacts on water quality

### Issues Not Discussed Further

The Initial Study for the proposed project assessed the impacts of the proposed project with regard to hazards and hazardous materials. It noted that other than the potential use of herbicides, which is analyzed in this section, the proposed project would not create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment, or emit hazardous emissions or handle hazardous or acutely hazardous materials within one-quarter mile of an existing or proposed school. The project site is not included in a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5, nor is it located on land within an airport land use plan or in the vicinity of a private airstrip. The project would not physically interfere with an adopted emergency response plan or emergency evacuation plan. Therefore these topics are not discussed further in the EIR, and this section focuses on the potential hazards

associated with herbicide use. The impacts of the proposed project with regard to the potential for a forest fire is analyzed in this EIR in Section 4.7 Hazards – Fire Hazards.

## 4.8.2 ENVIRONMENTAL SETTING

The Reserve is located on Mount Sutro, which rises to approximately 900 **f**eet at its peak. As a result, the topography is variable and sloping. An intermittent stream, Woodland Creek, flows down the hill's northeast flank. The site is almost entirely covered with non-native eucalyptus forest that was planted in the 1800s and has grown increasingly dense over the intervening years. The understory is dominated by poison oak and Himalayan blackberries and non-native species including English ivy, eucalyptus sprouts, and panic veldtgrass (*Ehrharta erecta)*. There are scattered patches of native vegetation, and a native plant restoration project at the summit. No special status plant species have been identified or are thought to occur on the site, with the exception of coastal triquetrella, a moss that could potentially occur within the Reserve.

As mentioned above, herbicides are not currently used for vegetation management in the Reserve. Vegetation management is generally limited to controlling invasive weeds adjacent to trails and in the native plant garden at the top of the forest, using hand labor. Under the existing management program, non-native vegetation has continued to spread, resulting in increased fire danger as well as decreased usability and ecological health. In addition, the spread of poison oak in areas easily accessed by the public and along trails has become a public safety concern. Based on the experience of other public land managers that demonstrates that the use of herbicides as part of the vegetation management process is substantially more effective than mechanical or manual control techniques, UCSF is considering the use of herbicides to help control target non-native plant species.

## 4.8.3 HERBICIDE USE ASSUMPTIONS

UCSF proposes to test the efficacy of using two main herbicides (Aquamaster® and Garlon 4 Ultra®) as part of its vegetation management program by applying them in one or possibly two Demonstration projects. Aquamaster (active ingredient is glyphosate) would potentially be applied in both foliar and cut-stump treatments and Garlon 4 Ultra (active ingredient is triclopyr butoxyethyl ester) would potentially be applied only for cut-stump treatments. Two adjuvants were also assessed to increase herbicide effectiveness and application accuracy: a surfactant (Competitor) and a dye (Blazon). Depending on the results of that testing, limited use of the herbicides may be expanded to manage target vegetation on about 80% of the Reserve.

Tree and understory removal would mainly be done using a large cutting machine (e.g., a "Brontosaurus") that chops up leaves, branches, and small stems and then distributes the cut material back on the ground surface as a rough mulch. Herbicides would be used to prevent resprouting of cut vegetation for a period of up to six years and then used to help manage trailside vegetation. Additional details of the proposed project are provided in the following sections.

Initially, herbicides would be used in one acre of Demonstration Project 1 ("South Ridge Area"), but not used in Demonstration Projects 2 ("Edgewood Avenue Area") and 3 ("North Side of Summit"). It will not be known whether herbicides would be used in the two-acre Demonstration Project 4 ("East Bowl Corridor") until after an outcome for Project 1 is complete; so, for the purpose of conservative analysis, it is assumed here that herbicides would be used in Demonstration Project 4. The analysis of risks that are summarized in this report addresses both the short-term impacts resulting from the treatment of Demonstration Projects 1 and 4 and long-term impacts resulting from subsequent treatment (and retreatment) of up to 48 acres of the Reserve. See Figure 4.8-1 for locations of the Demonstration Projects.

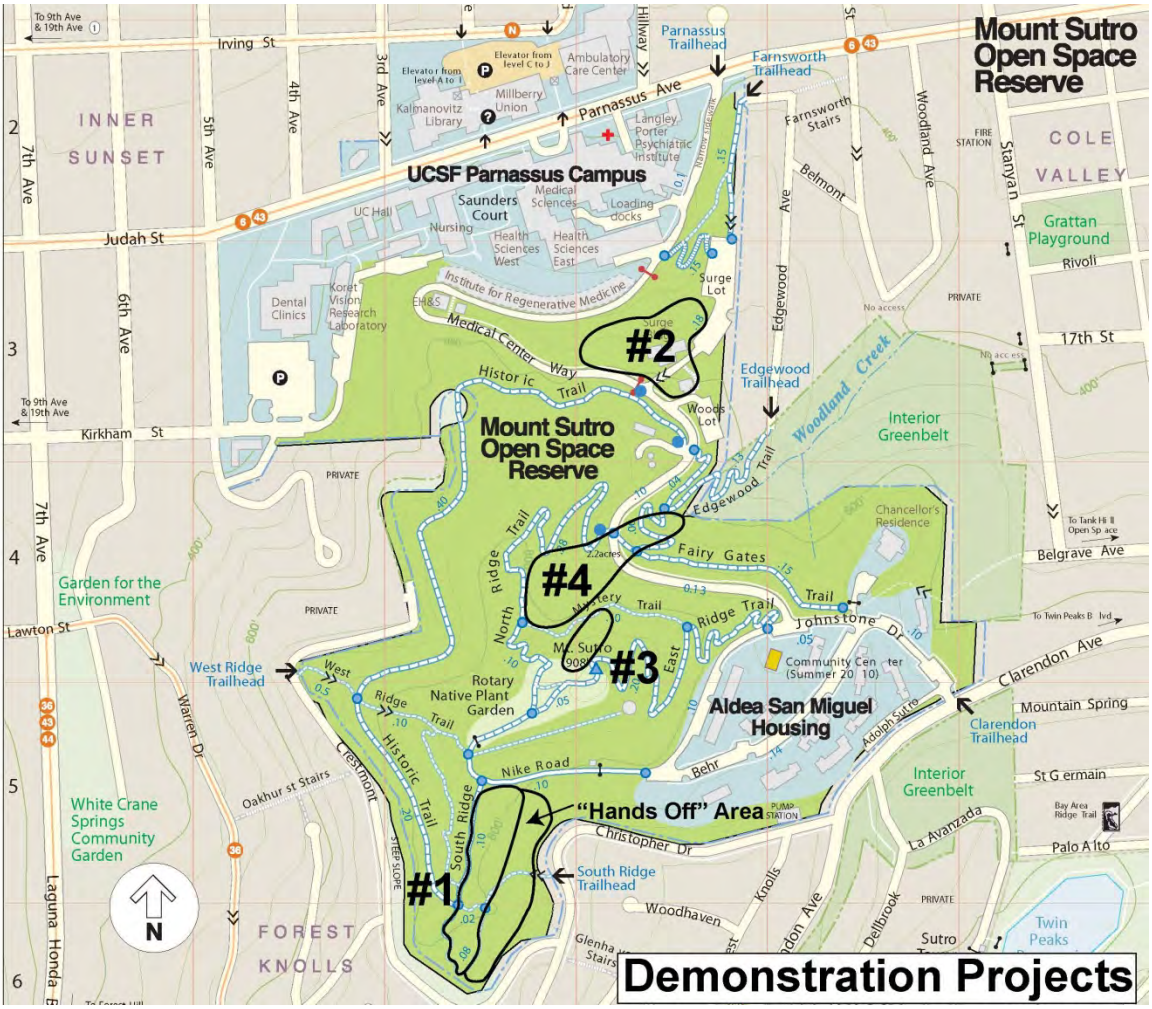



**Figure 4.8-1**
Proposed Demonstration Project Areas

The discussion presented below addresses impacts resulting from the Demonstration Projects and the long-term management of the Reserve.

## Target Plants

Plants to be treated include eucalyptus, acacia, broom, Himalayan blackberry, English and German ivy, panic veldtgrass (*Ehrharta erecta* - an invasive non-native grass), and poison oak (near trails).

## Initial Vegetation Treatment

Tree removal would be done using a large cutting machine (e.g., a "Brontosaurus") that chops up leaves, branches, and small stems and then distributes the cut material back on the ground surface as a rough mulch. For any trees too large for the cutting machine, trees would be cut using chainsaws. Felled tree trunks would be left on-site or chipped if feasible. Understory vegetation would be cut first (by machine where access is feasible, but otherwise by hand crews) in order to allow herbicide application before the stems are buried by the additional mulch generated by the tree removal. As described in subsequent sections, herbicide would be applied to cut stumps of the target species.

## Retreatment

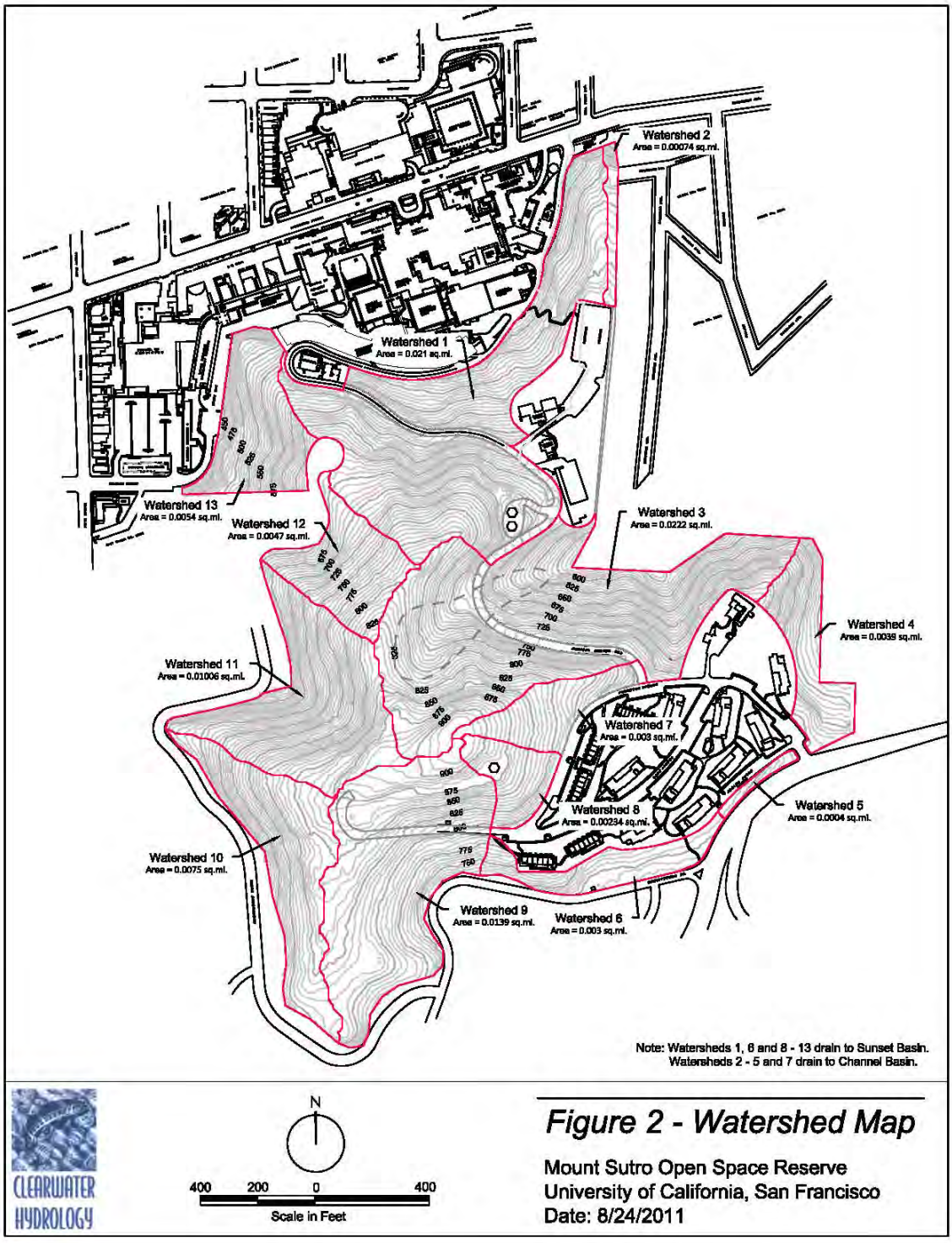
Some re-sprouting after the initial treatment is anticipated because not all cut stems would be adequately treated and/or because new plants would appear from seeds or underground roots that escape initial treatment. UCSF would spot-apply herbicide to retreat survivors, seedlings, or resprouts.

## Maintenance

Herbicide use for ongoing maintenance is evaluated in this report. This maintenance would occur along the trails and in the three native plant restoration areas (the existing area at the summit and two additional areas identified in the Management Plan) to remove target species (primarily panic veldtgrass, poison oak, non-native blackberry, and broom) from approximately ten feet on each side of the trail or within the restoration area. Maintenance would also be done in any other remnant native plant community that may be discovered.

## Exclusion Areas

Herbicides would not be applied within 100 feet of Christopher and Crestmont Drives (Watersheds 6, 9, 10 and 11) or the backyards along Edgewood Avenue (Watershed 2 on Figure 4.8-2). Garlon 4 Ultra® would not be applied within 50 feet of a stream. Herbicides would also not be applied to any area where no vegetation is removed, or to steep areas with sandy or gravelly soil. These areas, which are generally too steep and inaccessible for equipment, consist of pockets of forest along the western and eastern edges that are estimated to compose about 10-15% of the Reserve. For purposes of the risk assessment, it is assumed that 48 acres of the approximately 61 acre Reserve would be treated with herbicides. Given the variety of conditions under which herbicides would/would not be used and the variability in topography of the site, it




Source: Clearwater Hydrology

**Figure 4.8-2**
Mount Sutro Watershed Map

would be difficult to accurately map the exclusion areas. Therefore, a map of exclusion areas is not provided.

## Types of Herbicides

Herbicide use on the Reserve would be restricted to two specific products: Aquamaster® and Garlon 4 Ultra®. Aquamaster® (EPA Registration # 524-343) is a glyphosate-based product that was designed for use in and near aquatic ecosystems. As such, it does not contain the more hazardous surfactants contained in Roundup®, a more well-known glyphosate-based herbicide. Competitor® may be used as a surfactant with the Aquamaster® if needed for foliar treatment. Blazon® blue dye would be used as the marker dye (to indicate which plants have been treated). Garlon 4 Ultra® (formulated with modified seed oil, EPA Registration # 62719-527) may be used to treat tree stumps such as eucalyptus, acacia, and other non-native woody species that do not reliably respond to Aquamaster®. Garlon 4 Ultra® would be applied only to woody species. It would be applied only as a cut stump application.

## Application Rates and Treatment Targets

The following list describes the target usage and maximum application rates for proposed herbicides, surfactants and dyes when initially applied. It is expected that in many cases, the amount used would be significantly less than the amounts shown below because there are areas where the target plants are relatively sparse, so less than 1 quart of herbicide would be required for adequate treatment. Also, the amount would be substantially less during the five-year retreatment periods - just enough to treat any new sprouts or survivors, which are expected to decrease substantially with each year of retreatment based on the experiences in other forest management programs. Details of application rates are provided below.

**Aquamaster®** (53.8% Glyphosate, isopropylamine salt)
Target usage:

- Understory shrubs and vines — 1-5 quarts per acre (1.25 to 4 lb a.e./acre)[1]

**Garlon 4 Ultra®** (60.45% Triclopyr, butoxy ethyl ester)
Target usage:

- Cut stumps of trees — 1 to 4 quarts per acre (1-4 lb a.e./acre)

**Competitor®** (ethyl oleate, Sorbian alkylpolyethoxlate ester, dialkyl polyoxyethylene glycol)
Target usage:

- Surfactant for use with Aquamaster® — not more than 8 quarts per acre (14.8 lb a.i./acre)

[1] a.e. refers to the equivalent amount of active ingredient (a.i.) in the herbicide.

**Blazon®**

Target usage:

- Dye for use with both herbicides — 4 ounces per acre (0.28 lb a.i./acre)

This report assumes a maximum application rate of four pounds of active ingredient per acre for the initial treatment and Year 1 of retreatment; two pounds of active ingredient in Years 2-3 of retreatment, one pound of active ingredients per acre for Years 4-5 of retreatment (see Table 1). Based on the experience in other forest management programs, no more than one pound of active ingredients would be used per acre for ongoing maintenance (trailside and native restoration areas).

If herbicides are selected for future use after UCSF review of the results of vegetation management of the Demonstration Projects, then, at most, 12 acres a year would be treated at the four pounds of active ingredient per acre level. Additional acreage may be re-treated at the application rates described above, as necessary. The program of treatment and retreatment would occur annually for no more than six years on each 12-acre section. Maintenance treatment as described above would be ongoing.

## Application Methods

Herbicides would be spot applied by a wick, sponge, squirt bottle or a directed-spray applicator to cut stems or, for certain species such as panic veldtgrass (*ehrharta*) or poison oak (regrowing along trails), to foliage. All foliar applications would be of Aquamaster® (including Competitor® and Blazon®). Foliar applications would be applied directly to the target plant to minimize herbicide drift to non-target plants. UCSF has made a commitment to not conduct broadcast or widespread vegetation spraying.

The cut-stump method requires herbicide to be applied to stumps using a brush, backpack sprayer, squirt bottle, wick applicator or cutting tool-integrated applicator. The method is most effective when a stump is freshly cut (typically within 30 minutes), so most advice on application rates and methods focuses on immediate treatment. Water-based solutions of herbicide are sufficient if applied when a cut is fresh, whereas an oil mixture with herbicide is typically used for stumps not freshly cut.

## Herbicide Use Restrictions

The application of herbicides would comply with all label requirements on the herbicide containers, the additional guidelines described above, and the following specific Herbicide Use Restrictions. All these conditions were suggested by the consulting team to reduce the risk of using herbicides on the Reserve, and UCSF has agreed to include all these conditions as part of the proposed project.

1. Concentrated pesticide products are to be transported in a spill-proof, sealed container above and beyond the product container. The volume of concentrated product being transported on the site at any given time should be limited to less than 20 gallons
2. All trailheads and other access points leading to the treatment area will be closed during the day of application and posted prior to treatment in order to minimize exposures to the general public.
3. Blazon blue dye shall be used with all treatments to clearly delineate the treated areas, and the signs shall explain that contact with cut stumps and vegetation with visible dye should be avoided.
4. Treated areas will be posted for two weeks after the application to inform the general public of where applications have been conducted.
5. No applications will be conducted on weekends to minimize exposures to the general public.
6. All applications will be done by licensed applicators.
7. No applications should be conducted when wind speeds exceed the pesticide label-designated wind speeds (normally less than 10 mph) or in locations where prevailing winds might carry spray drift onto private property.
8. Any herbicide treatments will be conducted no earlier than June 1 to minimize the impact on nesting birds and no later than December 1, to avoid applications during the peak of the rainy season.
9. Within 30 feet (or within a feasible distance) of all roads and trails, areas to be treated should be mowed or pruned to knee height (approximately 2 feet) or lower prior to treatment to minimize exposure to the public and workers from contacting treated vegetation and reducing the probability of spraying honeybees and small mammals. No foliar applications should be made to vegetation above approximately shoulder height.
10. Applicators should spray in a downward direction to prevent spray drift from above.
11. Applicators will wear gloves, protective footwear, goggles, and coveralls. An eyewash bottle and extra pairs of clean gloves, soap, and water will be available in each vehicle for washing if workers are exposed.
12. Mixer-loaders will wear gloves, rubber boots, goggles, coveralls, and a protective apron.
13. All mixing and loading will be done in a manner to contain any spills that might occur during transfers and will not be done near a water body.
14. Spill cleanup materials will be available in all vehicles used for herbicide applications. Any vehicle transporting herbicide shall carry absorbent material on-board at all times in a quantity sufficient to contain a spill of the entire volume of herbicide being transported on the vehicle.
15. If workers accidentally spill herbicide on themselves, they will be required to stop work and wash the affected area as soon as possible.

The following triclopyr-specific (Garlon 4 Ultra®) guidelines would also be employed. Generally speaking, Garlon 4 Ultra® application leads to higher human and wildlife doses due to its higher dermal permeability and higher risks overall because of its higher toxicity in comparison to Aquamaster®. The following mitigations are designed to minimize hazardous exposures to Garlon 4 Ultra®:

1. No applications of Garlon 4 Ultra® will be conducted within 50 feet of a perennial or intermittent stream. Only Aquamaster® may be used within the streambed area, and when possible applications should be conducted early in the summer.
2. Two layers of gloves will be required for workers.
3. Backpack applicators that incorporate some form of physical separation between the backpack sprayer and the applicator are strongly recommended to prevent spills onto the applicator from a leaking backpack sprayer.

The City of San Francisco allows use of glyphosate and triclopyr on its Natural Resources Areas and other City lands with the only restrictions being compliance with the labels and a 3-day posting. The restrictions that UCSF has included as part of the project are more stringent than the herbicide labels or City requirements.

## 4.8.4 TREATMENT SCENARIOS

The *Herbicide Risk Analysis* conducted risk assessments for four treatment scenarios for consideration by UCSF in project planning. These hypothetical scenarios bracket the range of risks for the treatment schedule that has actually been proposed (as outlined in Table 1), and assume that approximately 12 acres of the 61-acre reserve are too steep and inaccessible to be treated. Areas too close to residences comprise roughly one acre of land and would be excluded from herbicide application. The herbicide application levels described in the "Maximum Treatment Scenario" exceed those that would be implemented.

1) **Maximum treatment scenario:** All accessible acres (48 total) treated at the maximum application rate of 4 lbs a.e./acre;
2) **Half-treatment scenario:** Half the accessible acres (24) treated at the maximum application rate or all of the acres treated at 2 lbs a.e./acre; and
3) **Quarter-treatment scenario:** One-quarter (12) of the accessible acres treated at the maximum application rate or all of the acres treated at 1 lb a.e./acre.
4) **Demonstration project scenario:** Treatment of Demonstration Project areas #1 (one acre) and #4 (two acres) at the maximum application rate of 4 lbs a.e./acre.

### Proposed Project Treatment Schedule

The amount of herbicide used on the Reserve in a given year affects the risk profile of the proposed project, specifically risks to aquatic animals and plants, risks to humans or animals drinking contaminated water, and risks to terrestrial mammals and birds eating contaminated vegetation, insects, or small mammals. UCSF has developed a treatment schedule, shown in Table 4.8-1 below, that would limit the amount of herbicide applied to the Reserve in any given year of the proposed project and thus minimize these risks.

In the initial treatment year of the proposed project, at most one-quarter of the 48 acres of the Reserve that is being considered for treatment with herbicides would be treated with herbicides at the maximum application rate of four pounds per acre. In the second year, a new area of 12 acres would be treated with the maximum application rate of 4 lbs. a.e./acre and re-sprouts on the

initial 12-acre plot would be treated with spot spraying up to 4 lbs. a.e./acre. Herbicide application rates would drop to a maximum of 2 lbs. a.e./acre in the third and fourth years and 1 lb. a.e./acre in the fifth and sixth years of the project. This program of treatment and retreatment would occur annually for no more than 5 years on each 12-acre section – see Table 4.8-1. There would also be maintenance treatment of up to 1 lb. a.e./acre, but once retreatment ends in year six this would only be done in limited areas.

**Table 4.8-1: Project Herbicide Treatment Schedule**

| | Maximum lbs per acre | Maximum Acres Treated | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year DP[b] | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 |
| Demonstration Projects | 4 | 3 | | | | | | | | | |
| Initial treatment | 4 | | 12 | 12 | 12 | 12 | | | | | |
| First retreatment | 4 | | | 12 | 12 | 12 | 12 | | | | |
| Second retreatment | 2 | | | | 12 | 12 | 12 | 12 | | | |
| Third retreatment | 2 | | | | | 12 | 12 | 12 | 12 | | |
| Fourth retreatment | 1 | | | | | | 12 | 12 | 12 | 12 | |
| Fifth retreatment | 1 | | | | | | | 12 | 12 | 12 | 12 |
| **Maximum annual** [a] | | | | | | | | | | | |
| Acres treated | | 3 | 12 | 24 | 36 | 48 | 48 | 48 | 36 | 24 | 12 |
| lbs applied | | 12 | 48 | 96 | 120 | 144 | 108 | 72 | 48 | 24 | 12 |

[a] Excludes maintenance use of herbicide (one pound per acre annual maximum) primarily along trails and native plant restoration areas, The Maximum Risk Assessment includes maintenance applications.

[b] "Year DP" indicates year of treatment for Demonstration Projects, which may or may not directly precede the following treatment years.

## 4.8.5 SIGNIFICANCE STANDARDS AND METHODOLOGY

### Significance Criteria

According to CEQA Guidelines, exposure of people, special status species, and sensitive habitats to hazardous materials may result in a significant impact. The CEQA Guidelines specifically list the following criteria that are pertinent to herbicide use on the Reserve. A project would have a significant impact if it met any of the following criteria:

- Creates a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials.

- Creates a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment.

- Emits hazardous emissions or handles hazardous or acutely hazardous materials,

substances, or waste within one-quarter mile of an existing or proposed school.

- Violates any water quality standards or waste discharge requirements.
- Substantially degrades water quality or results in additional siltation of either surface or groundwater.
- Has a substantially adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or the U.S. Fish and Wildlife Service.
- Has a substantially adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations or by the California Department of Fish and Game or the U.S. Fish and Wildlife Service.

## Methodology

The two herbicides, the surfactant, and the marker dye that may be used have all been approved by the Federal and State governments and the City of San Francisco for the type of proposed use on the Reserve. The two herbicides and the surfactant are on the City of San Francisco's approved list of herbicides, and they are used as part of the City's IPM program on City lands, including the Interior Greenbelt adjacent to the Reserve. No approvals are needed from any regulatory or responsible agency to use these materials so long as they are used per the criteria set forth on the labels. Nevertheless, UCSF has requested that additional analysis be conducted as part of this EIR to provide additional assessment of the potential hazards and risks associated with herbicide use.

It is noted that the City of San Francisco circulated the Draft EIR for its *Significant Natural Resource Areas Management Plan* in August 2011. That plan includes the use of herbicides (including Garlon® and Roundup® – a glyphosate-based herbicide) as part of the IPM program to manage invasive non-native species on Natural Resource Areas. That Draft EIR concluded that use of these and other herbicides to manage vegetation would have less-than-significant impacts on all biological and hydrologic resources as well as on human health.

The hazards and risks associated with herbicide use have been assessed in detail in the *Herbicide Risk Assessment* (Appendix G). Pertinent results are presented in the following impact discussions.

Risk assessment is defined as the qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants. ***Risk*** is a measure of the probability that damage to life, health, and/or the environment would occur as a result of a given hazard. The assessment of risk requires knowledge of the inherent toxicity of the chemical being assessed (the ***hazard***), the amount and time of ***exposure***, and the ***probability*** of that exposure occurring.

High toxicity alone does not necessarily equal high risk. If there are few routes of exposure or if organisms are only exposed to very small quantities of the chemical, risk is generally anticipated to be low. Exceptions to this "dose-makes-the-poison" paradigm are the low-dose effects observed from exposures to certain endocrine-disrupting chemicals. Endocrine disruption may occur at doses below those known to cause the type of toxicity that is typically evaluated in animal studies. These chemicals may be more toxic at very low doses than at moderate doses. Although information on endocrine disrupting potential is available for some pesticides in the peer-reviewed literature, the EPA is only now beginning a large-scale endocrine disruptor screening program for pesticides. Neither of the herbicide active ingredients (glyphosate and triclopyr butoxyethyl ester) and the other ingredients in the formulated products (modified seed oil), nor the surfactant and dye proposed for use on the Reserve have been classified as endocrine disrupting substances by the European Union, and no data were found in the scientific literature that would indicate that these chemicals have the capacity to disrupt endocrine function. Although studies on glyphosate-containing products that also contain certain surfactants as part of the formulation indicate that these products are capable of having endocrine-disrupting effects related to the presence of the surfactant, no endocrine-disrupting effects have been observed for exposure to glyphosate in the absence of these toxic surfactants. Because the Aquamaster® product contains only glyphosate and water, no endocrine-disrupting effects are anticipated, and adding Competitor® as a surfactant would not alter this conclusion.

### *Acute and Chronic Effects*

***Acute effects*** are short-term effects that occur close in time to exposure, within a few minutes to a few hours. ***Local effects*** are those that affect only the surfaces that come in contact with the pesticide, such as the eyes, skin, nose and throat. Under these circumstances, the chemicals do not enter the bloodstream or cause systemic illness. ***Systemic poisoning*** is an acute effect that occurs when a toxic chemical enters the bloodstream and is carried throughout the body, adversely affecting internal organs and body systems. In many cases of pesticide poisoning the most severe effects resulting in life-threatening illness and death are related to accidental or suicidal ingestions. ***Chronic health effects*** are long-term effects that include cancer, reproductive problems, impaired development and neurological disease, among others. The EPA assesses the risk of human chronic health effects of pesticides based on animal data required to register a product. Although human health studies may be available, the US EPA does not always include such epidemiological data in the risk assessment process. There are no human data available for most pesticides.

### *Epidemiological Studies*

Epidemiological studies provide information on the incidence of a disease or condition in a population and allow comparisons of health outcomes between exposed and unexposed groups of people. This information supplements the available animal data, and provides potentially useful information on exposure patterns. Epidemiological studies are not always available, but this information was included in the herbicide risk assessment where possible.

### *Assessing Impacts of Chemicals on Animals and Other Organisms*

The ecotoxicity sections of the *Herbicide Risk Assessment* provide a summary of known pesticide hazards to a variety of representative aquatic and terrestrial species. Chapters 3 and 4 of the risk assessment summarize available toxicity data for glyphosate and triclopyr for representative aquatic and terrestrial species. Toxicity endpoints from the available studies are compared to estimated environmental exposures to determine wildlife risks for the selected herbicides. Toxicity endpoints from the available studies are compared to estimated environmental exposures to determine wildlife risks for the selected herbicides. For glyphosate, which has been used extensively since 1974, this report summarizes the most relevant literature, but does not provide an evaluation of every available study. For triclopyr this report provides a comprehensive summary of peer-reviewed studies that are relevant to this project.

### *Exposure Assessment and Risk Characterization*

Exposure assessment involves estimation of exposures through all available routes, including drinking water, dermal contact, inhalation, and ingestion of contaminated food sources. A number of computer models have been developed to facilitate exposure analysis. The accuracy of the predictions obtained through modeling can be quite good if parameters used in the model are appropriate to the particular location and/or if model assumptions are correct. It is important to note that the risk calculations provide conservative estimates of Central, Upper and Lower exposures. In addition, most of the high-exposure scenarios are from accidental spills that can be prevented with sufficient care and attention by applicators.

To evaluate risk, ***exposure estimates*** are compared to a standardized reference value defined as the ***toxicity reference value (TRV)*** to obtain a ***hazard quotient (HQ)***, which is the ratio of the estimated exposure to the TRV. For humans, the TRV is defined as being the equivalent to US EPA's "***reference dose***" **(RfD)** (i.e., the level of exposure below which no adverse effects are anticipated). ***Thus, if the exposure has the potential to cause a known adverse health effect, then the hazard quotient would be greater than 1.0.*** Hazard quotients above one indicate that exposure exceeds the level of concern, and humans or wildlife may be at risk of adverse effects. These scenarios are flagged as potentially problematic and recommendations are made for avoiding them. Hazard quotients between 0.1 and 1.0 (see Table 4.8-2) suggest that though there are no known adverse health effects, there may be particularly sensitive individuals or species that may be affected. Hazard quotients below 0.1 indicate low levels of risk for the effects that have been studied and are represented by the TRVs. In this report, hazard quotients (HQs) less than one are reported as a percent of the TRV; HQs greater than one are reported as a multiple of the TRV (e.g. "the HQ was 2.4 times the TRV," or it was 2.4 times greater than the level below which no adverse effects are anticipated).

Men and children are assessed separately from women for Garlon 4 Ultra® (triclopyr) because this substance has been shown to cause birth defects in laboratory animals. Therefore, the risk threshold is lower for women of childbearing age, which leads to a higher estimate of risk for women compared to men and children by a factor of approximately 20. Consequently, in most

triclopyr exposure scenarios the worst-case scenario is assessed by its potential effects on a woman. All risk assessments are done per unit body weight, allowing men and children to be included in the same category.

The exposure analysis is divided into four broad categories: workers, the general public, terrestrial animals, and aquatic organisms. The following tables summarize the risk assessment.

**Table 4.8-2: Humans—Comparison of Herbicide Risks for Selected Exposure Scenarios**

| | | Central HQ Per Application Rate (lbs/acre/year) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Glyphosate Central HQ[a] | | Triclopyr BEE Central HQ[a] | | | | |
| | | | | Man or Child[b] | | Woman[b] | | Scenario Probability |
| | | 4 lbs | 1 lbs | 4 lbs | 1 lbs | 4 lbs | 1 lbs | |
| **Hazard to the General Public** | **Duration** | | | | | | | |
| **Dermal Contact with Contaminated Surface** | | | | | | | | |
| Vegetation contact – woman wearing shorts & T-shirt[b] | 1 hr | 0.0050 | 0.0012 | N/A[f] | N/A[f] | N/A[f] | N/A[f] | I / **Po** |
| Person sitting on a treated stump in shorts | 1 hr | 0.0004 | 0.0001 | 0.010 | 0.0025 | 0.12 | 0.029 | I / **Po** |
| **Consumption of Contaminated Water from Woodland Creek** | | | | | | | | |
| After a one-gallon spill of 2% foliar solution[h] | N/A | **1.6** | N/A[d] | N/A[f] | N/A[f] | N/A[f] | N/A[f] | HI / HI |
| After a one-gallon spill of 20% cut-stump solution[h] | N/A | **16** | N/A[d] | **32** | N/A[d] | **702** | N/A[d] | HI / HI |
| After Peak Herbicide Runoff into Woodland Creek,[i, j] Maximum Treatment Scenario | N/A | 0.0017 | 0.0004 | 0.0001 | 3E-05 | 0.0026 | N/A[d] | HI / HI |
| After Peak Herbicide Runoff into Woodland Creek, Demonstration Plot #4[k] | N/A | 0.0005 | 0.0001 | 3E-05 | 8E-06 | 7E-04 | N/A[d] | HI / HI |
| **Hazard to Herbicide Applicators** | **Duration** | | | | | | | |
| **Accidental Exposure to Cut-Stump Treatment Solutions[c]** | | | | | | | | |
| Wearing contaminated gloves | 1 min | 1E-05 | N/A[d] | 0.25 | N/A[d] | **5.5** | N/A[d] | **Pr** / **Pr** |
| | 1 hr | 0.0009 | N/A[d] | **15** | N/A[d] | **327** | N/A[d] | I / I |
| Spill on hands | 1 hr | 0.0019 | N/A[d] | 0.028 | N/A[d] | 0.62 | N/A[d] | I / I |
| Spill on lower legs | 1 hr | 0.0046 | N/A[d] | 0.064 | N/A[d] | **1.4** | N/A[d] | I / I |
| **Accidental Exposure to Foliar Treatment Solutions[e]** | | | | | | | | |
| Wearing contaminated gloves | 1 min | 1E-06 | N/A[d] | N/A[f] | N/A[f] | N/A[f] | N/A[f] | **Pr** / **Pr** |
| | 1 hr | 9E-05 | N/A[d] | N/A[f] | N/A[f] | N/A[f] | N/A[f] | I / I |
| Spill on hands | 1 hr | 0.0002 | N/A[d] | N/A[f] | N/A[f] | N/A[f] | N/A[f] | I / I |
| Spill on lower legs | 1 hr | 0.0005 | N/A[d] | N/A[f] | N/A[f] | N/A[f] | N/A[f] | I / I |
| **General Handling Exposure Using Backpack Sprayer, One Workday[g]** | | | | | | | | |
| Cut-stump treatment solutions | 7 hrs | 0.025 | 0.0062 | 0.91 | 0.23 | 0.99 | 0.25 | **HP** / **HP** |
| Foliar treatment solutions | 7 hrs | 0.026 | 0.0066 | N/A[f] | N/A[f] | N/A[f] | N/A[f] | **HP** / **HP** |

**Table 2 Notes:**

**HQ** = Hazard Quotient = the ratio of anticipated exposure to the RfD. RfD = reference dose, the dose below which no adverse effects are anticipated by EPA. Hazard Quotients greater than 0.1 are shaded in pink. Hazard Quotients greater than 1.0 are shaded in red. HQ 1: known adverse health effect. HQ between 0.1 and 1: affect sensitive individuals. HQ below O.1: low levels of risk (see text Exposure and Risk Assessment)

**Triclopyr BEE** (butoxyethyl ester) is the active ingredient in Garlon 4 Ultra®.

**Scenario Probability**. This is the probability of an event actually occurring. The first notation is for the Demonstration project and the second for overall Reserve treatment. **HP** = Highly Probable; **Pr** = Probable; **Po** = Possible; I = Improbable; and HI = Highly Improbable.

**Scientific Notation**: Hazard quotients less than 0.0001 are expressed in scientific notation. For example, 0.000008 would be expressed as 8E-6, also expressed as $8 \times 10^{-6}$.

[a] The Central Hazard Quotient is based on central assumptions of exposure and is considered the most likely exposure estimate. Upper and Lower HQs, which provide an estimate of worst-case and best-case scenarios, are listed in Chapters 3 and 4. HQ≥1: known adverse health effect. HQ between 0.1 and 1: sensitive individuals may be affected. HQ below O.1: low levels of risk (see text Exposure and Risk Assessment)

[b] Triclopyr exposure has been shown to cause birth defects in laboratory animals; therefore, the RfD is lower for women of childbearing age, which leads to a higher estimate of risk for women compared to men by a factor of approximately 20. A woman is considered in most triclopyr exposure scenarios to assess the worst-case scenario.

[c] The Central exposure estimate for cut-stump treatment solutions is for the herbicide products Aquamaster® and Garlon 4 Ultra® diluted to 20% product by volume.

[d] Not applicable as spill and spray exposures are on a per-event basis and do not change with herbicide application rate.

[e] The Central exposure estimate for foliar treatment solutions is for the herbicide products Aquamaster® and Garlon 4 Ultra® diluted to 2% product by volume.

[f] Not applicable as no foliar application of triclopyr is under consideration for the project.

[g] For general handling exposure for workers, the chronic RfD is used for comparison because it is assumed that workers are handling herbicide on a regular basis.

[h] A one-gallon spill into Woodland Creek resulted in the lowest Central risk estimates of any spill scenario; other spills considered in the risk assessment (20-gallon spills, spills into a puddle or pool) would all lead to exposures higher than the RfDs as well. Triclopyr values are presented here for 20% cut-stump solution only because no foliar treatment with triclopyr is proposed. Comprehensive spill scenarios are presented in Chapters 3 and 4.

[i] Herbicide concentrations in long-term runoff are predicted to be lower than for peak runoff, and do not exceed levels of concern. Herbicide concentrations for long-term runoff are presented in Chapters 3 and 4.

[j] The Maximum treatment scenario is all acres treated at the Maximum application rate of 4 lbs a.e./acre.

[k] The Demonstration Project #4 scenario is 2 out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb. a.e./acre.

**Table 4.8-3: Terrestrial Wildlife - Comparison of Herbicide Risks for Selected Exposure Scenarios**

| | Receptor | Glyphosate Central HQ[a] | Triclopyr Central HQ[a] | | | Scenario Probability |
|---|---|---|---|---|---|---|
| | | | Triclopyr BEE | Triclopyr Acid | TCP | |
| **Direct Spray of Small Mammal, 50% of Body Surface, First-Order Absorption** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | | 0.095 | 0.79 | N/A[b] | N/A[b] | I / **Po** |
| Foliar treatment solution, 2% herbicide concentration | | 0.0019 | N/A[c] | N/A[c] | N/A[c] | I / **Po** |
| **Acute Consumption of Contaminated Fruit, Vegetation, Insects or Small Mammals as 30% of Diet** | | | | | | |
| Consumption of contaminated fruit | Small mammal | 0.0028 | 0.0032 | N/A[b] | N/A[b] | **Po / Po** |
| Consumption of contaminated vegetation (grass) | Small mammal | 0.034 | N/A[c] | N/A[c] | N/A[c] | **Po / Po** |
| | Large bird | 0.024 | N/A[c] | N/A[c] | N/A[c] | I / I |
| Consumption of contaminated insects | Small mammal | 0.056 | 0.063 | N/A[b] | N/A[b] | **Po / Po** |
| | Small bird | 0.030 | 0.36 | N/A[b] | N/A[b] | **Po / Po** |
| Consumption of contaminated small mammal | Carnivorous mammal | 0.0050 | 0.0057 | N/A[c] | N/A[c] | I / **Po** |
| | Carnivorous bird | 0.0026 | 0.031 | N/A[c] | N/A[c] | I / **Po** |
| **Consumption of Water After a Spill into a 50-Liter Puddle/Pool of One Gallon of Herbicide[d]** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | Small mammal | **2.1** | **2.4** | N/A[d] | N/A[d] | I / I |
| | Carnivorous mammal | **1.2** | **31** | N/A[d] | N/A[d] | I / I |
| | Small bird | **1.3** | **16** | N/A[d] | N/A[d] | I / I |
| | Large bird | 0.2 | **2.2** | N/A[d] | N/A[d] | I / I |
| Foliar treatment solution, 2% herbicide concentration | Small mammal | 0.21 | N/A[c] | N/A[c] | N/A[c] | I / I |
| | Carnivorous mammal | 0.12 | N/A[c] | N/A[c] | N/A[c] | I / I |
| | Small bird | 0.13 | N/A[c] | N/A[c] | N/A[c] | I / I |
| | Large bird | 0.018 | N/A[c] | N/A[c] | N/A[c] | I / I |
| **Consumption of Contaminated Water After a Spill into Woodland Creek of 10 Gallons of Herbicide[d]** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | Small mammal | **12** | **14** | N/A[d] | N/A[d] | I / I |
| | Carnivorous mammal | **7.2** | **180** | N/A[d] | N/A[d] | I / I |
| | Small bird | 0.077 | 0.91 | N/A[d] | N/A[d] | I / I |
| | Large bird | 0.011 | 0.13 | N/A[d] | N/A[d] | I / I |
| Foliar treatment solution, 2% herbicide concentration | Small mammal | **1.2** | N/A[c] | N/A[c] | N/A[c] | I / I |
| | Carnivorous mammal | 0.72 | N/A[c] | N/A[c] | N/A[c] | I / I |
| | Small bird | 0.0077 | N/A[c] | N/A[c] | N/A[c] | I / I |
| | Large bird | 0.0011 | N/A[c] | N/A[c] | N/A[c] | I / I |
| **Consumption of Contaminated Water After Peak Herbicide Runoff into Woodland Creek[e]** | | | | | | |
| **Maximum Treatment Scenario[f]** | Small mammal | 1E-05 | 5E-07 | 4E-05 | 2E-05 | **Pr / Pr** |
| | Carnivorous mammal | 7E-06 | 7E-06 | 0.0005 | 1E-05 | **Pr / Pr** |
| | Small bird | 8E-06 | 3E-06 | 0.0003 | 8E-05 | **Pr / Pr** |
| | Large bird | 1E-06 | 5E-07 | 4E-05 | 1E-05 | **Pr / Pr** |
| **Demonstration Plot #4[g]** | Small mammal | 4E-06 | 2E-07 | 1E-05 | 6E-06 | **Pr / Pr** |
| | Carnivorous mammal | 2E-06 | 2E-06 | 0.0001 | 3E-06 | **Pr / Pr** |
| | Small bird | 2E-06 | 1E-06 | 7E-05 | 2E-05 | **Pr / Pr** |
| | Large bird | 3E-07 | 1E-07 | 1E-05 | 3E-06 | **Pr / Pr** |

**Table 3 Notes:**

**HQ** = Hazard Quotient = the ratio of anticipated exposure to the RfD. RfD = reference dose, the dose below which no adverse effects are anticipated by EPA. Hazard Quotients greater than 0.1 are shaded in pink. Hazard Quotients greater than 1.0 are shaded in red.

**BEE** = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid. Triclopyr BEE is the active ingredient in Garlon 4 Ultra®, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.

**Scenario Probability**. This is the probability of an event actually occurring. The first notation is for the Demonstration project and the second for overall Reserve treatment. **HP** = Highly Probable;

**Pr** = Probable; **Po** = Possible; I = Improbable; and HI = Highly Improbable.

**Scientific Notation**: Hazard quotients less than 0.0001 are expressed in scientific notation. For example, 0.000008 would be expressed as 8E-6, also expressed as $8 \times 10^{-6}$.

[a] The Central Hazard Quotient is based on central assumptions of exposure and is considered the most likely exposure estimate. Upper and Lower HQs, which provide an estimate of worst-case and best-case scenarios, are listed in Chapters 3 and 4. HQ≥1: known adverse health effect. HQ between 0.1 and 1: sensitive individuals may be affected. HQ below O.1: low levels of risk (see text Exposure and Risk Assessment)

[b] Triclopyr acid and TCP are degradation products of triclopyr BEE; they are not present in acute exposures such as direct sprays.

[c] No foliar application of triclopyr is under consideration for the project.

[d] A ten-gallon spill into Woodland Creek resulted in the lowest Central risk estimates of any spill scenario; other spills considered in the risk assessment (20-gallon spills, spills into a puddle or pool) would all lead to exposures higher than the TRVs as well. Triclopyr values are presented here for 20% cut-stump solution only because no foliar treatment with triclopyr is proposed. Comprehensive spill scenarios are presented in Chapters 3 and 4 of the Herbicide Risk Assessment.

[e] Herbicide concentrations in long-term runoff are predicted to be lower than for peak runoff, and predicted concentrations do not exceed 10% of any TRV. Concentrations for long-term runoff are presented in Chapters 3 and 4 of the Herbicide Risk Assessment.

[f] The Maximum treatment scenario assumes that all acres would be treated at the Maximum application rate of 4 lbs a.e./acre.

[g] The Demonstration Project #4 scenario assumes two out of the 7.08 accessible acres in the Woodland Creek watershed would be treated at the maximum application rate of 4 lb a.e./acre.

**Table 4.8-4: Aquatic Wildlife - Comparison of Herbicide Risks for Selected Exposure Scenarios**

| | Receptor | Glyphosate Central HQ[a] | Triclopyr Central HQ[a] | | | Scenario Probability |
|---|---|---|---|---|---|---|
| | | | Triclopyr BEE | Triclopyr Acid | TCP | |
| **Exposure to Contaminated Water After Spill into Woodland Creek of One Gallon of Herbicide[b]** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | Sensitive amphibians | **194** | **4,268** | N/A[c] | N/A[c] | HI / HI |
| | Sensitive fish | N/A[d] | N/A[d] | N/A[d] | N/A[d] | N/A[d] |
| | Sensitive aquatic invertebrates | **158** | **9,484** | N/A[c] | N/A[c] | HI / HI |
| | Aquatic plants | **35** | **304,836** | N/A[c] | N/A[c] | HI / HI |
| Foliar treatment solution, 2% herbicide concentration | Sensitive amphibians | **19** | N/A[b] | N/A[c] | N/A[c] | HI / HI |
| | Sensitive fish | N/A[d] | N/A[d] | N/A[d] | N/A[d] | N/A[d] |
| | Sensitive aquatic invertebrates | **16** | N/A[b] | N/A[c] | N/A[c] | HI / HI |
| | Aquatic plants | **3.5** | N/A[b] | N/A[c] | N/A[c] | HI / HI |
| **Exposure to Contaminated Water After Peak Herbicide Runoff** | | | | | | |
| **Maximum Treatment Scenario[e]** | | | | | | |
| Peak runoff to Oceanside Wastewater Treatment Plant[f] | Sensitive amphibians | N/A[d] | N/A[d] | N/A[d] | N/A[d] | N/A[d] |
| | Sensitive fish | 0.0005 | 0.0015 | 0.0001 | 0.0001 | **Pr / Pr** |
| | Sensitive aquatic invertebrates | 9E-05 | 0.0031 | 8E-06 | 3E-05 | **Pr / Pr** |
| | Aquatic plants | 2E-05 | 0.099 | 0.0008 | 5E-05 | **Pr / Pr** |
| Peak runoff into Woodland Creek[f] | Sensitive amphibians | 0.020 | 0.016 | 0.0010 | 0.020 | **Pr / Pr** |
| | Sensitive fish | N/A[d] | N/A[d] | N/A[d] | N/A[d] | N/A[d] |
| | Sensitive aquatic invertebrates | 0.016 | 0.036 | 0.0048 | 0.0065 | **Pr / Pr** |
| | Aquatic plants | 0.0036 | **1.1** | 0.52 | 0.010 | **Pr / Pr** |
| **Demonstration Plot #4[g]** | | | | | | |
| Peak runoff to Oceanside WWTP[f] | Sensitive amphibians | N/A[d] | N/A[d] | N/A[d] | N/A[d] | N/A[d] |
| | Sensitive fish | 0.0001 | 0.0004 | 3E-05 | 3E-05 | **Pr / Pr** |
| | Sensitive aquatic invertebrates | 3E-05 | 0.0009 | 2E-06 | 1E-05 | **Pr / Pr** |
| | Aquatic plants | 6E-06 | 0.028 | 0.0002 | 1E-05 | **Pr / Pr** |
| Peak runoff into Woodland Creek[f] | Sensitive amphibians | 0.0056 | 0.0045 | 0.0003 | 0.0056 | **Pr / Pr** |
| | Sensitive fish | N/A[d] | N/A[d] | N/A[d] | N/A[d] | N/A[d] |
| | Sensitive aquatic invertebrates | 0.0046 | 0.010 | 0.0014 | 0.0018 | **Pr / Pr** |
| | Aquatic plants | 0.0010 | 0.32 | 0.15 | 0.0028 | **Pr / Pr** |

**Table 4 Notes:**

**HQ** = Hazard Quotient, the ratio of anticipated exposure to the TRV. TRV = Toxicity Reference Value, the dose below which no adverse effects are anticipated in a wildlife population. Hazard Quotients greater than 0.1 are shaded pink. Hazard Quotients greater than one are bolded and shaded red.

**Triclopyr BEE** is the active ingredient in Garlon 4 Ultra®, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP. BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, a degradation product of triclopyr acid.

**Scenario Probability**. This is the probability of an event actually occurring. The first notation is for the Demonstration project and the second for overall Reserve treatment. HP = Highly Probable; **Pr** = Probable; **Po** = Possible; I = Improbable; and HI = Highly Improbable.

**Scientific Notation**: Hazard quotients less than 0.0001 are expressed in scientific notation. For example, 0.000008 would be expressed as 8E-6, also expressed as $8 \times 10^{-6}$.

[a] The Central Hazard Quotient is based on central assumptions of exposure and is considered the most likely exposure estimate. Upper and Lower HQs, which provide an estimate of worst-case and best-case scenarios, are listed in Chapters 3 and 4. HQ≥1: known adverse health effect. HQ between 0.1 and 1: sensitive individuals may be affected. HQ below O.1: low levels of risk (see text Exposure and Risk Assessment)

[b] A one-gallon spill into Woodland Creek resulted in the lowest Central risk estimates of any spill scenario; other spills considered in the risk assessment (20-gallon spills, spills into a puddle or pool) would all lead to exposures higher than the RfDs as well. Triclopyr values are presented here for 20% cut-stump solution only because no foliar treatment with triclopyr is proposed. Comprehensive spill scenarios are presented in Chapters 3 and 4.

[c] Not applicable as only triclopyr BEE is considered for acute spill scenarios because degradation to triclopyr acid and TCP occurs over a longer time frame.

[d] Not applicable - fish are not found in the seasonal Woodland Creek, so they were not evaluated. The Wastewater Treatment Plant (WWTP) scenarios were not evaluated for amphibians because amphibians only live in fresh water.

[e] The Maximum treatment scenario is all acres treated at the maximum application rate of 4 lbs a.e./acre.

[f] Herbicide concentrations at Southeast WWTP are predicted to be lower than at Oceanside WWTP because less of the treated area drains to the east. Herbicide concentrations in long-term runoff are predicted to be lower than for peak runoff and predicted concentrations do not exceed 10 percent of any TRV. Concentrations at both WWTPs and for long-term runoff are presented in Chapters 3 and 4.

[g] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

## 4.8.6 IMPACTS AND MITIGATION MEASURES

**Impact HAZ-1: Human Health Hazard. Use of proposed herbicides on the Reserve could pose a significant risk to human beings. (Less than Significant)**

As described in the Setting section, exposure to toxic levels of herbicides can cause adverse human health effects. The *Herbicide Risk Assessment* concluded that the proposed use of Aquamaster®, conforming to the proposed use rates and use restrictions, would not pose a significant health risk for the general public. For both foliar and cut-stump treatments using Aquamaster®, dermal exposures from contaminated vegetation do not exceed levels of concern for the general public for any scenario. Because the general public would not be exposed to herbicide residues for an extended period of time, there would be no chronic health effects on the general public.

Men and children are assessed separately from women for Garlon 4 Ultra® (triclopyr) exposure because this substance has been shown to cause birth defects in laboratory animals; therefore, the risk threshold is lower for women of childbearing age, which leads to a higher estimate of risk for women compared to men and children by a factor of approximately 20. Consequently, a woman is considered in most triclopyr exposure scenarios to assess the worst-case scenario.

For Garlon 4 Ultra®, sitting on a treated stump in shorts approaches, but does not exceed a level of concern for women. Because the area would be posted prior to herbicide application and the posting would remain for two weeks after application the potential for exposure would be reduced to a less-than-significant level. To further reduce this potential impact, the signs describing the herbicide treatment will advise people that plants that have been treated are marked by the color of the blue dye that would be added to the herbicide, and should be avoided. A direct spray of a person also approaches levels of concern, but the risk of people being exposed to direct sprays is extremely unlikely because the application would be made by experienced applicators who would not spray people, and is, therefore, not considered a significant impact.

For residences that border the Reserve, the probability of herbicide-contaminated runoff entering private property is very low, since most rainfall runoff from the Reserve is captured by storm drains before it can access private property. One small watershed (Watershed 2 – see Figure 4.8-2) borders private property along Edgewood Avenue, and treatment of this area could result in contaminated runoff entering the backyards of these residences and pose a health hazard. However, UCSF has already committed to not apply herbicides in this small watershed, thereby eliminating this potential risk.

The one area of residential development that has the potential to be affected by contaminated runoff from the Reserve consists of 10 - 12 residences located along Stanyan Street, Belgrave Avenue, and Clarendon Avenue. Portions of Watershed 4 (2.5 acres) drain towards these residences, and there is not an intervening storm drain to collect runoff prior to it reaching the residential yards. However, between the Reserve and these residences is the City-owned and

managed Interior Greenbelt that would act as a buffer zone, trapping much of the runoff before it reaches the yards. The *Herbicide Risk Assessment* concluded that even water in Woodland Creek that directly drains the Reserve (without a buffer) would not exceed the levels of concern for the herbicides evaluated. Any runoff from treated areas in Watershed 4 that traveled through the Interior Greenbelt buffer to the backyards of homes would contain substantially lower amounts of Aquamaster® or Garlon 4 Ultra® residues than the runoff in Woodland Creek. Therefore, the hazard, if any, of runoff from treated areas reaching these yards would be below the level of concern and be less-than-significant.

As there would not be broadcast spraying of any herbicide, and there would be treatment buffers near residential areas, the risk of spray residues escaping the Reserve and affecting the general public or students, patients, or workers at UCSF would not pose a significant risk.

Because risks associated with exposures from direct sprays, accidental spills, and contact with contaminated vegetation were calculated on a per-event basis, there is no difference in the risk profile between the several long-term treatment scenarios and the Demonstration Projects; however, it is likely that more exposure events (more individuals exposed or more exposures for a single individual) would occur for a larger treated area and would be proportional to the size of the treated area (for direct sprays and contact with contaminated vegetation), assuming exposed populations are evenly distributed. Without a detailed accounting of the number of visitors to a treated area or the wildlife populations in the treated area, no quantitative assessment of additive risk can be conducted. For direct sprays of small mammals and birds, the per-individual risk included in the table is a reasonable estimate of total risk because it is unlikely that the same animal would be sprayed again in another part of the reserve on the same day. For accidental spills, the additional precautionary measures that prohibit carrying more than 20 gallons of herbicide at a time will limit the maximum amount that could spill in any one event.

To summarize, the proposed use of Aquamaster® and Garlon 4 Ultra® would have ***less-than-significant impacts*** on human health, and no mitigation beyond the safeguards already included in the proposed project are required.

Though no mitigation is required, it is recommended that the following improvement measures be added to the Herbicide Use Restrictions:

1. Minimize the use of Garlon 4 Ultra® to reduce risks to workers, the general public, and wildlife. Aquamaster® appears to be equally effective in cut-stump treatments if stumps are treated immediately after cutting. This approach is particularly recommended for the watershed that borders on the Interior Greenbelt, since this is the only watershed that could produce runoff that enters private property.

2. Use the lowest concentrations of herbicide possible for cut-stump treatments. Efficacy studies indicate that concentrations of glyphosate and triclopyr products as low as five percent can be as effective as 50–100 percent solutions if stumps are treated immediately after cutting. Use of a more dilute herbicide solution will also allow for treatment of more trees per acre, thereby avoiding limitations in the number of trees that can be treated.

**Mitigation:** None required.

**Impact HAZ-2: Hazards to Applicators. Use of proposed herbicides on the Reserve could adversely affect herbicide applicators. (Less than Significant)**

Herbicide applicators can be exposed to herbicides through accidental spills or sprays that result in skin exposure and through the general exposure that occurs while working with herbicides, including brushing up against contaminated vegetation and inhaling spray mists. All of these exposures are considered to be likely. For the proposed project, the primary risks of concern to workers are from dermal and general exposures to Garlon 4 Ultra®. For Aquamaster®, none of the worker exposure scenarios analyzed exceeds threshold levels of concern.

The highest risk is for applicators exposed to an accidental spill of a cut-stump Garlon 4 Ultra® solution into a glove that was left unwashed for one hour, resulting in an estimated Central dose that is 327 times the Reference Dose (RfD). This scenario is unlikely if workers follow the guidelines of washing as soon after a spill as possible; however, even the more probable scenario of a spill left on the skin for one minute would result in a dose that is hazardous for women.

General worker exposures that occur from ordinary chemical handling and contact with treated surfaces and spray drift during the application also exceed levels of concern for triclopyr for women. General exposure estimates were calculated using the assumption that a spray applicator would be used for treating cut stems/stumps. However, if only a brush or wick applicator were used, risks could be reduced by approximately a factor of 10.

The highest risk to workers from glyphosate exposure would be that of general exposure for a worker conducting foliar sprays. However, none of the glyphosate scenarios exceeds an HQ of 0.1, so the risk is not significant.

Because all of the worker exposure estimates are on a per day or per-event basis, there is no difference in the risk between the Maximum treatment scenario and the Demonstration Projects.

The risks for workers can be reduced by requiring herbicide applicators to follow the Herbicide Use Restrictions listed in Section 4.8.3 and the additional restrictions listed under Impact 1. Particular attention should be paid to conducting rapid cleanup after spills, and to ensuring that Garlon 4 Ultra® applicators wear two layers of gloves and incorporate a form of physical separation between the backpack sprayer and the applicator to prevent dermal exposure from a leaking backpack sprayer. By implementing the guidelines, the impact would be reduced to a ***less-than-significant*** level. The improvement measures recommended for Impact 1 would further reduce risk for applicators.

**Mitigation:** None required.

**Impact HAZ-3: Terrestrial Wildlife Species. Use of proposed herbicides on the Reserve could adversely affect terrestrial wildlife. (Less than Significant)**

Terrestrial wildlife can be exposed to herbicides through direct sprays, by brushing up against treated vegetation or cut stumps, by drinking water contaminated by spills, and by eating contaminated food. Direct sprays are possible for small mammals and insects, although it is unlikely that a large number would be exposed in this way because of the highly targeted nature of the proposed treatments.

Exposures from ingesting contaminated food and water are more probable, especially for small mammals living on or near a treated site. Exposures for terrestrial wildlife exceed levels of concern for drinking contaminated water for both Aquamaster® and Garlon 4 Ultra® and from direct sprays with Garlon 4 Ultra®. Because any direct spraying would be done by a trained applicator, the likelihood of a significant number of small animals being sprayed is small. In addition, the only three special status species of animals identified as having the potential to occur on the Reserve (monarch butterfly, olive sided flycatcher, and western red bat) are aerial species and very unlikely to be sprayed. Direct spraying would be expected to have a less-than-significant impact on terrestrial wildlife.

The most probable exposure scenarios for terrestrial wildlife involve animals drinking contaminated water running off from treated sites into Woodland Creek, puddles, or pools. A spill into Woodland Creek would be diluted quickly, to the point that even worst-case estimates are well below levels of concern for all terrestrial wildlife modeled. Drinking water from pools or puddles or Woodland Creek after a spill of herbicide would be hazardous. However, the likelihood of spills occurring are very low given the safeguards built into the program.

A secondary concern is the possibility of wildlife consuming contaminated food, including vegetation, fruit or insects. The only possible risk (shown in Table 4.8-3) is of small birds eating insects contaminated with Garlon 4 Ultra®. While this is possible, the Central HQ is 0.36, which is well below the 1.0 threshold of a known health hazard for these birds.

There is a potential that ephemeral pools or puddles that may be used as drinking water sources for small mammals and birds could be contaminated by herbicide runoff from treated sites. The *Herbicide Risk Assessment* was unable to quantitatively estimate herbicide concentrations for this scenario because insufficient data were available, but based on U.S. Geological Survey studies of herbicide occurrence in water bodies near treated sites and in overland flow, and several other studies demonstrating high concentrations of herbicides in soils near cut-stump treatment sites, the report concluded that it is possible that small-volume puddles and pools could contain high concentrations of herbicides from runoff. The amount of herbicide in puddles could be minimized by using the lowest effective concentration of herbicide for cut-stump treatments (5% solutions), by filling in ruts or depressions near treatment sites, and by requiring applicator teams to clean up any spills to land immediately by adding absorbent material to the spill site and disposing of this material appropriately.

Because exposures from direct sprays, accidental spills, and contact with contaminated vegetation are on a per-event basis, there is no difference in the risk profile between the Maximum, Half, and Quarter treatment scenarios and the Demonstration Projects. For

consumption of contaminated food and water from puddles or pools, there may be no difference in risk between the Maximum treatment scenario and the Demonstration plots for individual animals living in a treated area if they eat and drink primarily from the treated area; however, population-level impacts would be lower if only the two-acre Demonstration plot is treated.

Impacts to the three special status terrestrial species, as well as to other terrestrial species, would be ***less-than-significant***, and no mitigation is required. However, due to the possible concern of wildlife drinking from contaminated puddles or pools, the following improvement measures are recommended, in addition to those identified under Impact 1:

1. Require applicators to clean up all spills to puddles and to land.

2. Fill in depressions where puddles might form near heavily treated areas (particularly near areas treated with Garlon 4 Ultra®) to reduce the potential for overland flow from treated sites to contaminate areas that could be used as amphibian breeding habitat.

**Mitigation:** None required.

**Impact HAZ-4: Water Quality and Aquatic Wildlife. Use of proposed herbicides on the Reserve could adversely affect water quality and aquatic wildlife. (Less than Significant)**

There are no special status species of aquatic wildlife on the Reserve, so potential impacts are limited to impacts to common species.

Runoff from treated sites can collect as puddles or pools on the site and run off the site via Woodland Creek and other smaller drainages. Herbicide residues can be transported by this runoff and adversely affect water quality. Aquatic wildlife, including amphibians, aquatic invertebrates, and algae can be exposed to herbicides through spills of herbicide into Woodland Creek and puddles or pools on the Reserve, as well as from herbicide runoff from treated sites. While the spill scenarios are unlikely, herbicide runoff is likely to occur if herbicide applications are conducted within a few months of the rainy season. Amphibians and aquatic invertebrates that breed in seasonal pools or puddles are especially at risk from both Aquamaster® and Garlon 4 Ultra®, with Garlon 4 Ultra® having higher toxicity to aquatic life.

The primary risks of concern for aquatic wildlife are spills of Aquamaster® or Garlon 4 Ultra® to Woodland Creek and to ephemeral puddles, which results in estimated doses from three to hundreds of thousands times the toxicity reference value for amphibians, aquatic invertebrates, and algae. Measures that are part of the project that would reduce the probability of contaminating water from accidental spills include limiting the mixing and loading of herbicide solutions to an area where spills can be contained, limiting the volume of herbicide that can be transported on-site, and transporting herbicides in a spill-proof, sealed container at all times. Such spills are considered highly improbable.

Because exposures from accidental spills are on a per-event basis, there is no difference in the risk profile between the Maximum, Half, and Quarter treatment scenarios and the Demonstration

Projects. For exposure to contaminated water in puddles or pools, there may be no difference in risk between the Maximum treatment scenario and the Demonstration plots for individual animals living in a contaminated puddle or pool; however, fewer pools would have the potential to be contaminated and population-level impacts would be lower if only the two-acre Demonstration plot is treated. For aquatic organisms living in Woodland Creek, there would be substantial differences in the amount of herbicide runoff into Woodland Creek between the Maximum, Half, and Quarter treatment scenarios and the Demonstration plots that is directly proportional to the area treated. One mitigating factor is that Woodland Creek only drains a small part of the Reserve (9 acres, of which only 7 would be treated because of inaccessibility to 2 acres), so the amount of runoff would be limited. Runoff from the other watersheds on the Reserve would be intercepted by the storm drains that would direct the flow to the wastewater treatment plants, where the runoff is further diluted by inflows from other portions of San Francisco and finally by the receiving water in the San Francisco Bay and the Pacific Ocean.

Contaminated runoff from sites treated with Garlon 4 Ultra® to Woodland Creek exceeds levels of concern for aquatic plants such as algae (though not by a large margin). Levels of concern for amphibians, fish, or invertebrates are not exceeded. However, there is a possibility that pools or puddles could be contaminated by herbicide runoff from treated sites. As noted above, no quantitative estimate of herbicide concentrations could be made for this scenario because insufficient data were available. While it is possible that aquatic wildlife might drink or be immersed in a contaminated puddle near a recently treated area, this limited and short-term impact to common aquatic wildlife species is considered ***less-than-significant.*** Potential impacts to algae would also be both short-term and limited, and are considered ***less-than-significant.*** Nevertheless, the previously recommended measures to use the lowest effective concentration of herbicide for cut-stump treatments. filling in ruts or depressions near treatment sites, and requiring applicator teams to clean up any spills to land immediately are recommended for inclusion in the program.

**Mitigation:** None required.

**Impact HAZ-5: Regional Water Quality and Aquatic Wildlife and Fish. Use of proposed herbicides on the Reserve could adversely affect water quality and aquatic wildlife in San Francisco Bay and the Pacific Ocean. (Less than Significant)**

The concentrations of herbicides in runoff from the Reserve were estimated at both the Southeast and Oceanside Wastewater Treatment Plants (WWTP) for peak runoff occurring during the 5-year storm event for the four treatment scenarios (Maximum, Half, Quarter and Demonstration Projects) and risks were estimated for fish, aquatic invertebrates, and aquatic plants in the San Francisco Bay and the Pacific Ocean near the WWTP outfalls. Estimated concentrations of Aquamaster® and Garlon 4 Ultra® in runoff that reaches the San Francisco Bay and the Pacific Ocean were found to be very low and would not pose a hazard to aquatic life. The impact would be ***less-than-significant***, and no mitigation is required.

**Mitigation:** None required.

**Impact HAZ-6: Impacts to Vegetation. Use of proposed herbicides on the Reserve could adversely affect native vegetation, including special status species of plants. (Less than Significant)**

Because herbicide applications would be applied directly to target invasive species using directed application methods, the likelihood of herbicides being applied to non-target plants is small. Nevertheless, directed spray applications, particularly during maintenance, could adversely affect non-target vegetation. Most of the understory vegetation in the treatment areas is comprised of invasive species. Removal of these species and allowing revegetation by more native species would be an overall benefit to Reserve habitat. The use of herbicides greatly increase the efficacy of efforts to eliminate non-native and invasive species. Therefore, even if there was some minor spray drift or inadvertent spraying of some native species, the number that could potentially be killed would be small, and the benefits of providing additional habitat diversity substantially outweighs the impact.

There is one special status species of plant that may occur on the Reserve (though no specimens have actually been found). This is the coastal triquetrella (*Triquetrella californica*), which is a moss that grows on soil, gravels, and rocks along trail sides and within grassy areas with rocks. It is not expected that these types of habitat would be treated as they do not support the target invasive species. Even if this moss does occur on the Reserve, it would likely not be damaged or killed by proposed herbicide applications. To conclude, the impact of herbicide applications on special status species of vegetation and native plants in general would be ***less-than-significant***, and no mitigation is required.

**Mitigation:** None required.

**Impact HAZ-7: Impacts from Surfactant and Dye. Use of the proposed surfactant and dye would not substantially increase the risk identified in the previous six impacts. (Less than Significant)**

While the surfactant may not be needed for cut stump treatment (as Aquamaster® and Garlon 4 Ultra® do not require the addition of a surfactant for effective treatment), Competitor® may be added when conducting foliar treatments or follow-up treatments that involve a combination of cut stump and foliar applications. The marker dye Blazon® would be used with both types of herbicide to ensure that all target plants are treated as well as to identify treated stumps and foliage for the general public.

The *Herbicide Risk Assessment* concluded that the addition of the surfactant Competitor® and/or the marker dye Blazon® to the Aquamaster® would not significantly increase the risk of injury due to the small amount that would be used and the fact that the surfactant and dye do not substantially increase the toxicity of glyphosate. The use of the selected surfactant and dye do not increase the severity of impacts identified in the previous six impact discussions. It is noted that a principal reason that UCSF selected Aquamaster® for use is that its combination with the surfactant Competitor® does not result in any new or more significant risk than that posed by the

glyphosate itself. Roundup,® on the other hand, is a glyphosate-based herbicide that is pre-packaged with additives that cumulatively present more risk to human health and the environment than glyphosate does on its own.

**Mitigation:** None required.

**Impact HAZ-8: Cumulative Impacts. Use of the proposed herbicides on the project site could combine with herbicide applications on the adjacent Interior Greenbelt to adversely affect water quality and aquatic wildlife. (Less than Significant)**

As described above under Impact 4, project impacts to water quality and common aquatic wildlife species are considered less-than-significant. Potential impacts to algae would be both short-term and limited, and are considered less-than-significant.

The City of San Francisco owns and manages the Interior Green Belt natural area, which is adjacent to Sutro Forest. The City's Natural Areas Program was contacted regarding herbicide applications in this natural area, which includes a new hiking trail above the east side of Woodland Creek. They reported that they had not applied herbicide in the Interior Green Belt in the past two years[10]. They are unable to predict whether they would apply herbicides along this trail or elsewhere in that greenbelt in the next ten years.[11] If the City applied herbicides above Woodland Creek in the same season that they were applied on that part of the Reserve draining to Woodland Creek, there would be more herbicide residues entering the creek. It remains unknown when and if the City would apply herbicides, but it is expected that even if there was a concomitant applications, the combined residues would have a less-than-significant cumulative impact. On these bases, there is no evidence that there would be a cumulative impact beyond the impacts described above for the project. In any case, the improvement measures recommended for the project would reduce the project's increment to any possible cumulative impact to a ***less-than-cumulatively considerable level***.

**Mitigation:** None required.

[10] Randy Zebell, personal communication, April 26 & 27, 2012.
[11] Lisa Wayne, personal communication, April 26, 2012.

# 4.9 HYDROLOGY

## 4.9.1 INTRODUCTION

This section discusses the potential impacts of the proposed project with regard to hydrology on the site and surrounding area. The Initial Study for the proposed project noted that the proposed project would not result in significant hydrology or water impacts, and that the topic would not be studied further in the EIR. However, public comments raised during the Initial Study/Notice of Preparation comment period indicated continued concerns about project impacts to water runoff from Mount Sutro, as well as impacts to water quality resulting from herbicide use. Therefore, the proposed project's impact on hydrology and water quality is analyzed in this EIR. This section includes an analysis of water runoff as well as other hydrology issues, and includes an analysis of water quality impacts resulting from herbicide use. Herbicide use impacts are also analyzed in Section 4. 8 Hazards – Herbicide Use.

The analysis was prepared by Clearwater Hydrology. The impacts associated with the proposed project are compared with the thresholds of significance adopted by the California Environmental Quality Act (CEQA).

Comments related to hydrology received during the Initial Study/EIR scoping process included concerns about the following:

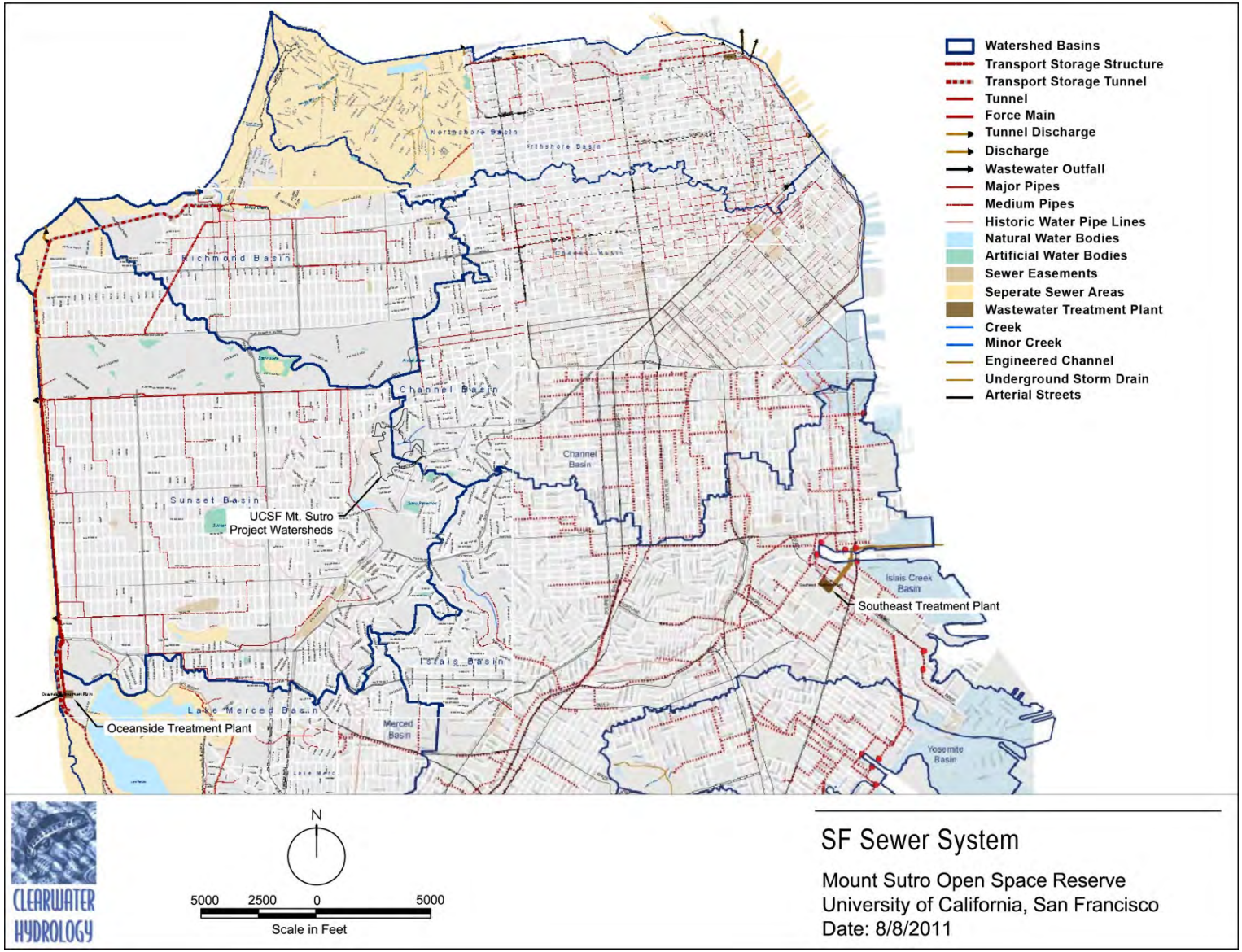
- Impacts to drainage patterns and water runoff
- Impacts on water quality

## 4.9.2 ENVIRONMENTAL SETTING

### Regional Hydrologic Setting

The Mount Sutro Reserve ("project area") occupies 61 acres of ridgeline and hillslopes adjoining the drainage divide that forms the boundary between the San Francisco Bay and Pacific Ocean watersheds in the City of San Francisco (See Figure 4.9-1, San Francisco Regional Sewer System map). Accordingly, project area surface drainage derived from rainfall ultimately drains to storm drain inlets in the headwaters of either the Channel Basin or the Sunset Basin and is conveyed east or west, respectively, in the City's Combined Sewer System (CSS) to either the Southeast or Oceanside water treatment plants (WTPs), where it is treated prior to being discharged to Central San Francisco Bay or the Pacific Ocean.

The CSS is a network of pipes and tunnels that convey combined stormwater and sanitary sewage flows, referred to as combined sewer discharge, to City water treatment plants. Cumulatively, during non-storm conditions, the City's CSS collects and treats up to 80 millon gallons per day (MGD) of wastewater, primarily municipal sewage. During rainstorms, these facilities can collect and treat more than 500 MGD. The treatment plants normally employ a minimum of secondary treatment to the combined inflows, before discharging the effluent to SF




Source: Clearwater Hydrology

**Figure 4.9-1**
San Francisco Regional Sewer System Map

Bay or the Pacific Ocean. However, depending on individual storm characteristics as well as the timing between storms, the treatment plant capacities can be overwhelmed resulting in the discharge of minimally treated flows to the Bay and/or the Ocean. Under current conditions, such overflows are expected to occur from one to ten times a year (John Gregson, SF Water Dept., personal communication, 8/1/11; museumca.org/creeks/1690-OBSFSewers.html).

Mean annual rainfall for north central San Francisco (Richmond District gage) is 20.0 inches (Western Regional Climate Center, www.wrcc.dri.edu). Local orographic influences in the uplands of Mount Sutro elevate this total to 21-22 inches.[1] The rainy season for San Francisco's Mediterranean-type climate normally extends from October through March. However, the project area maintains relatively moist soil conditions wherever dense stands of vegetation occur during those summer months when fog and related fog drip are persistent. The highest temperatures (and therefore the driest conditions) tend to occur from late-August through early-October. Substantial floods occur in response to Pacific frontal-system storms of 3-5 days duration, with nested bursts of high-intensity rainfall. For the higher elevation zones of SF, such as the project area, flooding is localized and occurs periodically due to obstructed storm drains, plugged catch basin inlets or undersized drain segments.

Soils in the project area are mapped by the Natural Resources Conservation Service (NRCS) under a single map unit: Candlestick-Kron-Buriburi complex, 30 to 75 percent slopes. These soils are typically fine to gravelly loams and belong to the "D" hydrologic soil group, which indicates rapid runoff generation and a high erosion hazard.[2] A prior slope stability risk assessment prepared for the UCSF Parnassus campus lands noted that on-site soils were thin over primarily chert bedrock of the Franciscan formation and typically measured a few feet or less in thickness.[3]

Land use in the project area is primarily eucalyptus forest with an intermingled understory of native and non-native coastal scrub. Secondary uses include hiking trails, paved and non-paved access roads, and parking lots.

## Local Hydrologic Setting

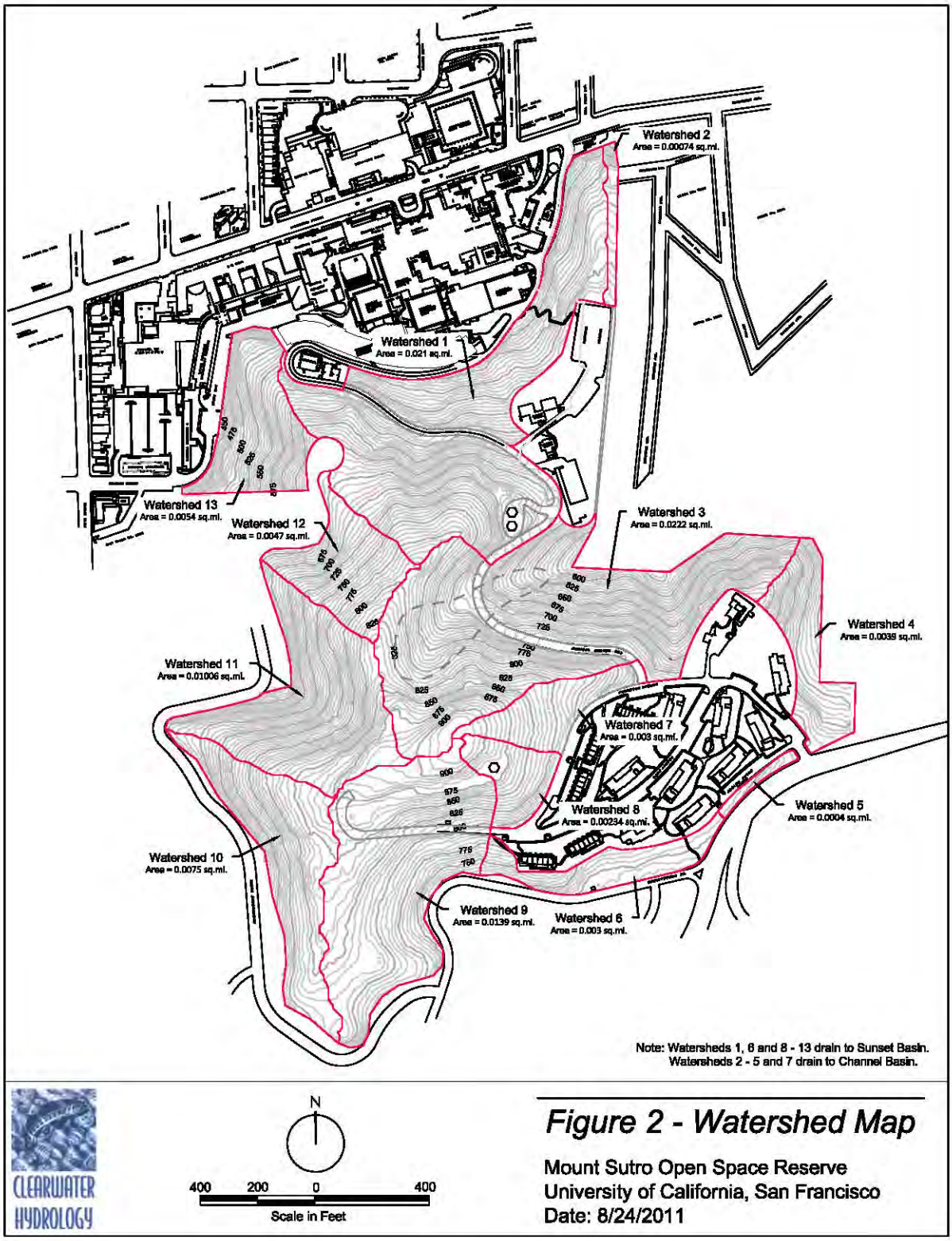
***Surface Drainage Characteristics***

Figure 4.9-2 is a watershed map of the project area. The site topographic mapping was derived from digital elevation model (DEM) data that was procured during the aforementioned slope

[1] Climate of San Francisco, NOAA, http://www.wrh.noaa.gov/mtr/sfd_sjc_climate/sfd/SFD_CLIMATE3.php and *Mean Annual Precipitation and Precipitation Depth-Duration-Frequency Data for the San Francisco Bay Region, California*. US Geological Survey Open-File Report, S.E. Rantz, 1971.

[2] Web Soil Survey, National Cooperative Soil Survey, USDA, Natural Resources Conservation Service, http://websoilsurvey.nrcs.usda.gov.

[3] Slope Stability Risk Assessment, University of California San Francisco, San Francisco, California, 25 August 2006. Prepared by Rutherford & Chekene, SF, CA.




Source: Clearwater Hydrology

**Figure 4.9-2**
Mount Sutro Watershed Map

stability risk assessment and reconfigured at a coarser grid spacing by the EIR hydrologist to generate a map suitable for watershed delineation and parameter evaluation.[4]

Thirteen watersheds were delineated based on the mapped topography and the location of local storm drainage outlets, typically storm drain catch basins (see Figure 4.9-2). Elevations of project area watersheds range from 915 feet NAVD (National Geodetic Vertical Datum) along the principal north-south trending ridgeline to 450 feet NAVD at the Watershed 13 outlet on Koret Way. Aside from the principal ridgeline and several contiguous spur ridges, watershed slopes typically exceed grades of 20 percent and reach as high as 60 percent. Three developed areas that also drain to the three of the established watershed outlets (Watersheds 1, 5 and 6) were excluded from the mapped watersheds, since they lie outside of the Mount Sutro Reserve boundary and would not be subject to modification as part of the project. Catch basin and/or storm drain inlet or outlet locations were determined by reference to UCSF maps, discussions with the principal on-site facilities engineer[5] and on-site inspections of the watershed and adjoining perimeter lands. Of the 13 delineated watersheds, eight (Watersheds 1, 6 and 8-13) are contained within the Sunset Basin and five (Watersheds 2-5 and 7) within the Channel Basin.

Surface runoff typically encompasses overland flow, shallow concentrated flow and channel or storm drain flow components. Overland flow occurs in the zones along and immediately adjacent to the ridgelines. Runoff then concentrates into swales or other small defined channels, and eventually reaches roadways either within or contiguous to the project area. Here runoff is typically directed to storm drain catch basins and conveyed in the CSS to the Oceanside or Southeast WTPs. The exception is Watershed 3, which ultimately discharges to Woodland Creek via either overland flow or a storm drain outfall structure. This outfall structure collects upslope and roadway runoff that enters a roadside catch basin along Medical Center Way. Field inspection of the outfall structure indicated that it was either completely filled with sediment, or more likely, was intended to infiltrate the collected runoff into the coarser substrate underlying the bed of Woodland Creek. During more significant runoff-producing storms, the infiltration capacity of this coarse sediment within the outfall pipe will be overwhelmed by the incoming stormwater discharge and the pipe with overflow onto the adjoining vegetated slope and drain overland to the channel. Woodland Creek eventually discharges to the CSS in the vicinity of Stanyan Street.

UCSF maintains the storm drains and other stormwater collection features that occur on its property. The SF Department of Public Works (SFDPW), Hydraulics Section, provides the engineering services to the SFPUC for the public sewer infrastructure. The SFPUC (San Francisco Public Utilities Commission) monitors and maintains the CSS (Combined Sewer System) facilities within City limits, and oversees system operation, system component upgrades (i.e. replacement)

[4] The original LiDAR (Light Detection and Ranging) -derived DEM comprised gridded point data at 2 ft. horizontal spacing, which was too refined for purposes of hydrologic evaluation. The contouring shown in Figure 4.9-2 represents the modified point spacing of 8 feet, which eliminated irrelevant anomalies in the mapping (e.g. tree stumps, minor surface depressions). Elevations are referenced to the California State Plane Coordinate System (U.S. survey feet, NAD83 HARN horizontal datum, NAVD88 vertical datum).

[5] Personal communications with UCSF Facilities Chief Engineer, Donn Carpenter, Parnassus campus, July-August 2011.

to major force main and transport/storage structures, and the operation of the principal water treatment plants including the Oceanside, Southeast and North Point WTPs.

The SFDPW's Hydraulics Section guidelines for storm drain design require that the 5-yr. recurrence interval design storm be conveyed within the receiving storm drains without street flooding. Excess runoff from rainstorms exceeding the 5-yr. design event that triggers shallow street flooding is permitted as long as the local flood depths are not excessive and downgradient components of the storm drain system can successfully convey the overflow.[6]

***On-Site and Downstream Flooding***

The Federal Emergency Management Agency (FEMA) in association with the City and County of San Francisco are in the process of finalizing a Flood Insurance Study (FIS) and a Flood Insurance Rate Map (FIRM) for the City of San Francisco (AECOM Risk MAP- http://www.bakeraecom.com/index.php/california/san-francisco-county/). This first issuance of FIS/FIRM documentation is part of the City of San Francisco's application to join the National Flood Insurance Program (NFIP). However, at present, neither the FIS nor the FIRM has been officially adopted by FEMA.[7]

The project area occupies primarily ridgeline lands and steep adjoining uplands at elevations well above the 100 and 500 year flood zones. However, roadway catch basins obstructed by sediment or debris (e.g. eucalyptus bark or trash) may cause localized ponding of stormwater and nuisance flooding. Such localized flooding is typically not considered or depicted in regional flood mapping. For example, the Reserve lands are not shown as areas subject to flooding on maps prepared by the City Department of Emergency Management (http://www.sfdem.org/index.aspx?page=4 and http://www.sfdem.org/ftp/uploadedfiles/DEM/PlansReports/HazardMitigationPlan.pdf ).

***Erosion and Sedimentation***

The project area's predominantly fine to coarse-grained loam soils are relatively shallow and occupy moderate to steep slopes. These soils are susceptible to erosion particularly when exposed to concentrated surface flow. The potential for erosion is increased when established vegetation is disturbed or removed during normal construction activity. Under existing land use conditions, infrequent mass wasting processes pose the greatest risk for erosion and downstream sedimentation, although erosion along the steeper hiking trail segments with the Reserve can occur during more intense rainstorms. The July and August 2011 field inspections of site drainageways and culvert inlets and outlets suggested the prevalence of relatively stable swales in the bulk of the Reserve's watersheds. Also, there was no evidence of any significant instability within the on-site portion of the Woodland Creek channel. The more mildly sloping terraces adjoining this channel provide some opportunities for deposition of sediments

[6] EIR hydrologist personal communication with Cliff Wong, Engineer, SFDPW, Infrastructure Design and Construction, Hydraulics Section, SF, CA.
[7] Federal Emergency Management Agency. http://www.msc.fema.gov/webapp/wcs/stores.

transported by upslope surface runoff. The summer inspections showed some minor sedimentation along roadway gutters, but all catch basin inlets were clear of obstructing debris.

***Groundwater***

Data on the local groundwater system are sparse. The UCSF slope stability risk assessment[8] included a geologic cross-section figure compiled from project area boring logs and surface expressions of geologic unit. In the majority of the Reserve area, primarily upslope of Medical Center Way, soils are thin and groundwater likely occurs as seasonal seepage along the lithologic contact with the overlying soil mantle. In lower elevation zones, particularly on the flanks of Woodland Creek, colluvial deposits are likely to store more subsurface water. However, none of the project area would be classified as supporting a sustainable groundwater supply.

## Water Quality

***Overview***

The quality of stormwater runoff under existing watershed conditions is likely excellent over the majority of the project area, although no actual field data were available for review. Urban land use is minimal, restricted to secondary roadway and driveway segments. Therefore, project area stormwater is relatively free of automotive pollutants. It should be noted that developed areas adjoining the Reserve lands include moderate to high density residential and commercial/institutional land uses that typically yield elevated levels of stormwater contaminants, including heavy metals and pesticides. Vegetation in the project area is a mix of native and non-native woodland and coastal scrub. Sediment yield from the project site is variable and corresponds in magnitude to the intensity of rainfall and antecedent soil moisture conditions in the site watersheds, as well as local slope steepness and geomorphic features (e.g. opportunities for toe of slope deposition). However, in the absence of frequent slope failures, the nearly continuous vegetal cover maintains relatively low rates of soil loss from the project area.

The project area is within the jurisdictional drainage area boundaries referenced in the Water Quality Control Plan for both the San Francisco Bay Basin ("Basin Plan") [9] and the Water Quality Control Plan for Ocean Waters of California ("Ocean Plan").[10] The most recent amendment to the Basin Plan was adopted by the State Water Resources Control Board and the USEPA in 2004, while the most recent Ocean Plan amendments were adopted by those same regulatory entities in 2006. The SF Bay Basin includes all watershed lands that drain directly to San Francisco, San Pablo and Suisun Bays, as well as substantial portions of coastal Marin, San Francisco and San Mateo counties. The Basin Plan is intended to protect and enhance stormwater quality and the beneficial uses identified for the significant water bodies that receive stormwater runoff from the

[8] Rutherford & Chekene, ibid.

[9] *Water Quality Control Plan--San Francisco Bay (Region 2)*, San Francisco Bay Regional Water Quality Control Board (RWQCB), adopted June 1995, with most recent Plan amendments adopted in 2004.

[10] *California Ocean Plan: Water Quality Control Plan- Ocean Waters of California*, State Water Resources Control Board and US EPA, latest amendments adopted Feb. 2006. Additional 2011 amendments to the 2006 Ocean Plan are currently undergoing legal and environmental review.

Basin. The Ocean Plan applies to point source discharges to the territorial waters of the State outside of enclosed bays, estuaries, and coastal lagoons. Beneficial uses listed in the Plans for Central San Francisco Bay and the nearshore Pacific Ocean include:

Central San Francisco Bay: Commercial Fishing (COMM), Shellfish Harvesting (SHELL), Migratory Fish Habitat (MIGR), Estuarine Habitat (EST), Fish Spawning (SPWN), Wildlife Habitat (WILD), Industrial Service Supply (IND), Industrial Process Supply (PROC), Navigation (NAV), Preservation of Rare and Endangered Species (RARE) and Contact and Non-Contact Recreation (REC1, REC2).

Pacific Ocean (SF and San Mateo Counties): Same as the beneficial uses cited above for Central SF Bay, except excluding PROC and adding Marine Habitat (MAR).

The current 303(d) list of impaired water bodies, maintained by the San Francisco Bay Regional Water Quality Control Board (RWQCB) and approved by the USEPA in June 2007, cites Central San Francisco Bay as impaired for pesticides chlordane, DDT, and dieldrin, and for dioxins, mercury (dissolved and sediment), furan compounds, exotic species, PCBs and selenium. While several beach areas along the San Francisco and San Mateo County coastlines are cited as impaired for coliform or other indicator bacteria, none of the receiving water zones in the vicinity of the Oceanside Water Treatment Plant is listed. Under the direction of USEPA, the RWQCB evaluates each impairing water quality constituent and if necessary, develops a Total Maximum Daily Load (TMDL) for that constituent. The TMDL and its implementation plan serve to attain and maintain water quality standards for the impaired water body. A list of current TMDLs and projected time frames for implementation of additional TMDLs are available on the SF Bay RWQCB website: http://www.waterboards.ca.gov/water_issues/programs/tmdl/303d_lists2006_epa.shtml. Of the TMDLs completed thus far for Central San Francisco Bay, including those for mercury and urban creeks pesticide toxicity, none is directly applicable to the proposed Project and its projected vegetation management and treatment options.

One particularly sensitive resource located southwest of the project area is Laguna Honda Reservoir. This reservoir is maintained by the City of San Francisco as an emergency drinking water source. Thus, the water quality of any surface water or groundwater inputs is critical.[11] Based on a review of the on-site and off-site drainage facilities in and adjacent to the project area, none of the runoff from project area watersheds would be directed toward Laguna Honda Reservoir. The reservoir is located at the toe of a near vertical bedrock wall with little or no recharge area upslope, and thus was well positioned to limit potential contaminant influxes from either surface or groundwater sources.

[11] EIR hydrologist's personal communication with John Gregson, Ph.D., Senior Chemist, SF PUC/WWE Pretreatment Program, San Francisco, CA.

## 4.9.3 REGULATORY SETTING

The following summarizes federal, State, and local regulatory programs, laws, and policies related to the proposed project.

### Federal Laws and Regulations

The Federal Water Pollution Control Act (commonly referred to as the Clean Water Act [CWA]) of 1972, as amended in 1987, prohibits the discharge of pollutants into waters of the United States unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Section 402(p) of the 1987 amendments established a framework for regulating municipal, industrial and construction stormwater discharges under the NPDES program. In California, NPDES permits are issued through the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs). The quality of surface waters in San Francisco Bay and the territorial waters of the Pacific Ocean, as well as groundwaters, are also regulated under provisions of the State's Porter-Cologne Act, which was enacted in 1969 to maintain water quality in California.

The City and County of San Francisco operates the Oceanside and Southeast Water Treatment Plants (referred to by USEPA and RWQCB- Region 2 as the Oceanside and Southeast Water Pollution Control Plants) and their related transport and outfall facilities under the regulatory provisions in NPDES Permits No. CA0037681 and CA0037664, and the Waste Discharge Requirements (WDRs) cited in Orders No. R2-2009-006212 and R2-2008-000713, respectively. The Orders stipulate protocols for the monitoring of dry and wet weather WTP influent and effluent and limitations on sampled constituents of concern. For the Oceanside WTP, the Order's influent limitations apply to 5-day biological oxygen demand (BOD5), total suspended solids (TSS) and pH. During wet weather conditions, the list of monitored constituents in plant influent expands to include ammonia, oil and grease, pesticides and PCBs (poly-chlorinated biphenols), PAHs and other selected inorganic and organic contaminants. Herbicide monitoring is not monitored under the Order. For the Southeast WTP, the applicable Order addresses dry-weather influent limitations for BOD5, TSS, and flow rates. Normal dry weather effluent contaminants of concern expand to include oil and grease, pH, total residual chlorine, heavy metals, dioxins, ammonia and other constituents. For normal wet weather conditions not involving untreated system overflows to Central SF Bay, influent monitoring is restricted to flow rates, while

---

[12] *Order R2-2009-0062 Waste Discharge Requirements for the City and County of San Francisco: Oceanside Water Pollution Control Plant (Southwest Ocean Outfall) and Collection System, including the Westside Wet Weather Facilities*. SF Bay Regional Water Quality Control Board (Region 2), Oakland, CA. Effective date: Oct. 1, 2009. http://www.swrcb.ca.gov/rwqcb2/board_decisions/adopted_orders/2009/R2-2009-0062.pdf

[13] *Order R2-2008-007 Waste Discharge Requirements for the City and County of San Francisco: Southeast Water Pollution Control Plant (Southeast Plant), the North Point Wet Weather Facility, the Bayside Wet Weather Facilities, and the Wastewater Collection System within the City and adjoining service areas*. SF Bay Regional Water Quality Control Board (Region 2), Oakland, CA. Effective date: April 1, 2008. http://www.swrcb.ca.gov/rwqcb2/board_decisions/adopted_orders/2009/R2-2009-0062.pdf.

monitored effluent constituents/parameters include those of flow rate, chemical oxygen demand (COD), bacteria, heavy metals, oil and grease, chlorine residual, heavy metals, ammonia, cyanide and acute toxicity. The Southeast WTP also maintains a pretreatment program for CSS flows. According to J. Gregson of SFPUC, herbicides are not sampled or otherwise monitored as part of the influent/effluent monitoring or pretreatment monitoring programs.

Section 404 of the federal Clean Water Act regulates the discharge of fill into Waters of the United States, including adjacent wetlands. Filling and/or disturbance of delineated wetlands requires a Department of the Army Fill Permit, issued by the Regulatory Branch of the US Army Corps of Engineers. Channel maintenance activities such as streambank protection and construction of outfall structures are routinely covered by Nationwide Permits, while more significant disturbance typically requires more substantial regulatory involvement and oversight, including approval of adequate impact mitigation.

## State Laws and Regulations

In California, the State Water Resources Control Board (SWRCB) and the nine RWQCBs issue NPDES permits. Communities with populations over 100,000, high-risk industries identified by the United States Environmental Protection Agency (USEPA), and construction projects of five acres or more must obtain an NPDES permit under NPDES Phase I regulations. On Sept. 2, 2009, the State Water Resources Control Board (SWRCB) updated the NPDES General Construction Storm Water Permit (SWRCB Order No. 2009-009-DWQ, NPDES General Permit No. CAS000002)14to apply to sites as small as one acre. Consequently, developments, redevelopments or construction disturbance of one acre or more require the filing of a Notice of Intent (NOI), Stormwater Pollution Prevention Plan (SWPPP), and other compliance-related documents with the State Water Resources Control Board, as well as the appropriate permit fee.

The California Department of Fish and Game (CDFG) also maintains jurisdiction over wetlands, as well as streams. Section 1602 of the State Fish and Game Code vests permitting authority to CDFG for any activity that may substantially modify a river, stream or lake. Typically, CDFG will take jurisdiction over small creeks and drainageways with defined bed and banks. Thus, headwater swales that do not exhibit any developed channel form are usually outside of CDFG jurisdiction.

## Local Regulations and Policies

Article 4.2 of the San Francisco Municipal Code, entitled "Sewer System Management" defines a development project as any activity that cumulatively disturbs 5,000 sq. ft. or more of land. Such projects are required to prepare a Stormwater Control Plan (SCP) for on-site and off-site water quality maintenance that adheres to guidelines adopted by the SFPUC and the SF Port

[14] State Water Resources Control Board Order No. 2009-0009-DWQ (As Amended by Order No. 2010-0014-DWQ) National Pollutant Discharge Elimination System General Permit No. CAS000002: Waste Discharge Requirements for Discharges of Storm Water Runoff Associated with Construction and Land Disturbance, issued Sept. 2, 2009, amended and adopted Nov. 16, 2010, effective date Feb. 14, 2011.

Commission. These guidelines specify requirements pertinent to the selection, design and maintenance of post-construction, stormwater Best Management Practices (BMPs). The SCP generally includes an operation and maintenance component specifying person(s) responsible for annual (at a minimum) inspection of stormwater controls/measures and the submission of annual self-certification reports to the City.

## 4.9.4 SIGNIFICANCE STANDARDS

According to the Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment with regard to hydrology if it would:

***Water Quality***

- Violate any water quality standards or waste discharge requirements.
- Substantially degrade water quality.

***Drainage***

- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or off-site.
- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level.
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner, which would result in flooding on- or off-site.
- Create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff.
- Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects.

***Flooding***

- Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map.

- Place within a 100-year flood hazard area structures that would impede or redirect flood flows.

- Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam.

***Seiche, Tsunami, and Mudflow***

- Result in inundation by seiche, tsunami, or mudflow.

## 4.9.5 IMPACTS AND MITIGATION MEASURES

### Project Assumptions

The proposed project will entail a program of vegetation management that will include targeted management actions potentially applied to lands comprising the Reserve. For purposes of this hydrologic impact assessment, all lands except for the "Hands-Off" Area are assumed to be subject to all of the proposed vegetation management actions noted in the Project Description, which may include the following:

Trees

- Removal of all vines on tree trunks up to about 10 feet in height.

- Prune branches as needed to remove fire ladders and hazards.

- Removal of dead and unhealthy trees.

- Tree thinning of remaining trees to average trunk spacing of 30 feet, except in Demonstration Area #4, where the average trunk spacing would be roughly 60 feet.

- Tree stump treatment and sprout control would depend on the outcome of Demonstration Projects, and could include techniques such as covering with tarps, sprout cutting, or goat grazing, but for purposes of this analysis, it is assumed, as a worst-case scenario, that herbicides will be used.

- Selective planting of native shrubs and trees, although natural recruitment of natives will be relied upon to a great extent.

Understory

- Initially, mechanically remove (via mowing, cutting) up to about 90% of the non-native biomass (shrubs and trees), as well as some poison oak along trails. Large areas of underbrush are expected to be maintained, and steeper slopes (>40 percent) may not be cut at all; however, for purposes of the assessment all of the area outside of the "Hands-Off" Area is assumed to be subject to some form of cutting and removal.

- Re-growth control may be conducted using various techniques including mowing, goat grazing, and/or herbicides, which would be applied annually or every other year for 5 years, depending on the rate of re-growth.

For mechanical removal and cutting, the project proposes to use either hand tools (e.g. pruning tools, weed wackers) or a mobile mastication machine, such as the "Brontosaurus". This machine can be mounted on a rubber-tired skid steer to mow at ground level, or on an excavator or gradall to masticate trees and higher brush. For any trees too large for the Brontosaurus, trees would be cut using chainsaws. Felled tree trunks would be left on-site or chipped if feasible. On steeper slopes, a cable high lead yarder may be used for tree removal in order to limit ground disturbance.

Masticated and cut material will be left on-site, with the masticated material utilized as mulch. In addition, trees will be cut above-ground and tree stumps and roots will be left intact. Bared areas created during the mowing that are not covered automatically by the cut residue will be covered with excess mulch generated by the mowing and mastication process, which should generate significant volumes of mulch as its by-product.

## Peak Flow and Runoff Volume Assessment

The EIR hydrologist conducted an assessment of pre- and post-project peak flow rates and runoff volumes for the delineated Project watersheds. Due to the suite of vegetation management actions that could be employed, the flood hydrograph package HEC-HMS[15], developed by the US Army Corps of Engineers, was chosen for the simulation of rainfall and runoff characteristics. HEC-HMS includes a SCS (Soil Conservation Service) unit hydrograph rainfall-runoff option which allows for the modeling of different soil and land use types, vegetation condition, and land management actions, such as land clearing, mulch application, and grading practice, where applicable.

In accordance with the City's drainage design guidelines, a 5-yr., 24-hr. rainstorm was selected for the model simulations. As noted in the Setting sub-section, significant rainstorms in the San Francisco Bay Region are typically of 3-5 days duration, punctuated by nested cloudbursts. So the 24-hr. duration represents a more intense period of rainfall within this typically longer rainstorm event.[16] The total storm rainfall for the modeled 5-yr., 24-hr. rainstorm was 3.30 inches.

The runoff curve number (CN) is the principal parameter defined in the SCS rainfall-runoff model for computing rainfall abstractions (e.g. interception, depression storage) and soil moisture retention, which comprise the portion of rainfall that does not contribute to surface

[15] *Hydrologic Modeling System, HEC-HMS, Version 3.5, August 2010*. US Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

[16] Rainfall distribution within the 24-hr. storm period was in accordance with the SCS Type IA rainstorm. The SCS mapping of the boundary between the regions for which the Type IA and Type I rainstorm distributions are delineated is poorly defined, so the simulations utilized the more intense Type IA distribution. Based on the centroid position for the composite project area watershed.

runoff. The CN value is influenced by the soil types and their related Hydrologic Soil Groups (HSGs), the watershed antecedent (pre-storm) moisture condition (dry, average or wet) and land use. CN values typically range 30 to 98, with the higher values representing less pervious or severely compacted surfaces, and the lowest values associated with denser vegetal cover in soils classified as HSG "A". For the current assessment, an average antecedent soil moisture condition was used.

All soil types mapped by the NRCS for the project area are categorized as HSG "D", which denote more rapid runoff production. Land use types within the project area watersheds are limited to woodland, brush (coastal scrub), and paved roadway segments. For the pre-project condition, proportional distribution of these land use types assumed an average, existing tree trunk spacing of 10 feet on-center (o.c.), with a 10 ft. diameter canopy, and intervening areas in brush in good condition. The SCS TR-55 manual presents tabular listings of cover types, HSGs and associated CNs, and defines brush as "brush-weed-grass mixture, with brush the major element."[17]

For the post-project condition, the trunk spacing for the remaining trees was assumed at 30 ft. o.c., or 60- ft. o.c. for the area associated with Demonstration Area #4 (East Bowl Corridor). A slightly broader canopy of 15 feet was assumed for this condition, given the likelihood that larger trees would comprise a greater proportion of the thinned woodland. The composite CN values for the individually modeled pre-project and post-project conditions were computed based on the area proportions of each land use within the modeled watershed. The increased area outside of the woodland canopy was assumed to remain in brush in good condition. While the area actually covered by standing brush will diminish in the post-project condition, areas of standing brush will be maintained while the mowed or cut areas will be covered in a layer of mulch. In portions of the treated areas, this mulch layer could reach several inches in thickness. Also, tree stumps and brush will be cut above ground leaving the rooting systems intact to provide continued binding of soils during the development of succession vegetation. The CNs for woodland and brush, both in good condition and in HSG "D" are listed as 77 and 73, respectively, which indicates that the brush is less efficient than woodland in generating runoff. Presumably, this is due primarily to the lower density of ground cover under the tree canopy. Note that even if the brush areas were assigned a "fair" condition rather than a good condition, the CN for brush would match that for woodland (CN=77). "Poor" condition brush would connote a condition wherein 50% of the treated area would be assumed bared area, which could not occur within the Project's vegetation management prescriptions.

Table 4.9-1 is a summary of the results of the flood hydrograph modeling conducted for the project area for the 5-yr., 24-hr. rainstorm under the pre- and post-project watershed conditions. As shown, the post-project condition will result in a slight reduction in both peak flow rates (Qp in cfs, cubic feet per second) and runoff volumes for each of the Project watersheds. Detailed

[17] *Urban Hydrology for Small Watersheds: TR-55*, USDA, Natural Resources Conservation Service, Conservation Engineering Division, Technical Release 55, June 1986.

modeling assumptions, input parameter values and computed watershed hydrographs are included in Appendix H.

**Table 4.9-1**
**Summary of HEC-HMS Model Simulations for Project Watersheds for Pre-Project and Post-Project Watershed Conditions: 5-Yr., 24-hr. Storm**

| Watershed | Area (ac.) | Pre-Project Qp (cfs) | Post-Project Qp (cfs) | Pre-Project Runoff (ft3) | Post-Project Runoff (ft3) |
|---|---|---|---|---|---|
| 1 | 13.36 | 3.34 | 2.79 | 62,806 | 56,307 |
| 2 | 0.47 | 0.12 | 0.10 | 2,101 | 1,869 |
| 3 | 14.21 | 2.94 | 2.40 | 62,651 | 55,381 |
| 4 | 2.49 | 0.59 | 0.48 | 11,018 | 9,797 |
| 5 | 0.26 | 0.07 | 0.05 | 1,134 | 1,009 |
| 6 | 1.93 | 0.46 | 0.38 | 8,547 | 7,601 |
| 7 | 1.94 | 0.42 | 0.34 | 8,520 | 7,578 |
| 8 | 1.50 | 0.32 | 0.27 | 6,593 | 5,864 |
| 9 | 8.87 | 1.72 | 1.40 | 38,814 | 34,498 |
| 10 | 4.83 | 1.03 | 0.84 | 21,231 | 18,866 |
| 11 | 6.44 | 1.41 | 1.15 | 28,353 | 25,198 |
| 12 | 2.99 | 0.68 | 0.55 | 13,207 | 11,739 |
| 13 | 3.46 | 0.80 | 0.65 | 15,291 | 13,593 |

## Sediment Yield Assessment

The proposed project will not introduce new areas of impervious surface within the delineated watersheds. However, since the proposed project will possibly alter the areal coverage and condition of a significant portion of these lands, the potential impact of the proposed management actions on sediment yield at the downslope watershed outlets was assessed by the EIR hydrologist. The Modified Universal Soil Loss Equation (MUSLE)[18] was used to compute the pre- and post-project watershed sediment yields. The MUSLE is an event-based equation, utilizing the parameters of the general Universal Soil Loss Equation (USLE) and watershed peak flow rate and runoff volume to compute sediment eroded from the landscape and delivered to the watershed outlet. In contrast, the USLE and its revised version, the Revised Universal Soil Loss Equation (RUSLE), compute the annual quantity of soil eroded from a watershed, but must be coupled with a sediment delivery ratio to convert this bulk total into actual yield. Use of the MUSLE allowed the assessment to be linked more directly to the peak flow and runoff volume results of the event-based HEC-HMS hydrograph modeling.

The MUSLE is represented as:

$S = 95*(Q*qp)^{0.56} * K * LS * C * P$

[18] Williams, Jimmy R. "Sediment Yield Prediction with Universal Equation Using Runoff Energy Factor", In *Present and Prospective Technology for Predicting Sediment Yields and Sources*, USDA, Agricultural Research Service, ARS-S-40, June 1975.

Where Q= volume of runoff , ac-ft.
qp= peak flow rate, cfs
K= soil-erodibility factor
LS= slope length and gradient factor
C= cropping management factor
P= erosion control-practice factor

The Q and qp values for each watershed were taken from the results of the HEC-HMS modeling. The K value were obtained from the NRCS Web Soil Survey, which for the common HSG "D" soils mapped for the project area was 0.24. Mean watershed slopes (s) and slope lengths (l) were determined based on the AutoCAD topographic mapping and input to an equation relating these parameters to the LS factor. Watershed C and P values were interpolated from Table 5.6 of Goldman[19]. The C factor value for the pre-project condition was that cited for undisturbed "native" vegetation (0.01), while for the post-project condition, the value was increased to 0.018 due to the substitution of a mix of remaining undisturbed brush and densely applied, masticated mulch. The P factor value for both pre- and post-project conditions was assumed to be 1.0, which represents an unmanaged condition.

The results of the MUSLE modeling are shown in Table 4.9-2. Given the direct proportional relationship between the event sediment yield and the LS, C and P factor values, the computed yields are very sensitive to even small changes in any one of them. The resulting 50% increase in post-project sediment yields is considered to be a worst-case scenario of complete (90%), concurrent cutting of all brush outside of the thinned tree canopy, and minimal opportunities for sediment deposition upslope of the watershed outlets. In reality, a significant portion of Reserve lands occupy ridgeline areas with mildly undulating topography and significant opportunities for sediment deposition. The more likely post-project scenario would be a phased program of thinning and understory cutting. This would significantly lower the post-project increase in sediment yield due to the continued presence of islands of uncut brush and the development of new vegetal cover in those areas cut during prior years. Moreover, the rooting systems of brush and trees that are cut will be left intact, continuing their soil-binding function for several years.

[19] Goldman, S. et al. 1986. Erosion and Sediment Control Handbook. Mc-Graw Hill Co.

**Table 4.9-2**
**MUSLE Watershed Sediment Yields for the 5-Yr., 24-Hr. Design Rainstorm**

| Watershed | Area (ac.) | K | LS | C Pre- Post- | P | Pre-Proj. Y (tons) | Post-Proj. Y (tons) |
|---|---|---|---|---|---|---|---|
| 1 | 13.36 | 0.24 | 28.44 | 0.01 (0.018) | 1.0 | 15.63 | 23.95 |
| 2 | 0.47 | 0.24 | 8.10 | 0.01 (0.018) | 1.0 | 0.10 | 0.15 |
| 3 | 14.21 | 0.24 | 38.93 | 0.01 (0.018) | 1.0 | 19.90 | 29.70 |
| 4 | 2.49 | 0.24 | 20.62 | 0.01 (0.018) | 1.0 | 1.61 | 2.43 |
| 5 | 0.26 | 0.24 | 5.82 | 0.01 (0.018) | 1.0 | 0.04 | 0.06 |
| 6 | 1.93 | 0.24 | 10.05 | 0.01 (0.018) | 1.0 | 0.60 | 0.90 |
| 7 | 1.94 | 0.24 | 17.33 | 0.01 (0.018) | 1.0 | 0.97 | 1.46 |
| 8 | 1.50 | 0.24 | 20.22 | 0.01 (0.018) | 1.0 | 0.85 | 1.28 |
| 9 | 8.87 | 0.24 | 21.25 | 0.01 (0.018) | 1.0 | 6.16 | 9.26 |
| 10 | 4.83 | 0.24 | 23.85 | 0.01 (0.018) | 1.0 | 3.70 | 5.56 |
| 11 | 6.44 | 0.24 | 40.78 | 0.01 (0.018) | 1.0 | 8.86 | 13.33 |
| 12 | 2.99 | 0.24 | 30.77 | 0.01 (0.018) | 1.0 | 2.89 | 4.34 |
| 13 | 3.46 | 0.24 | 44.43 | 0.01 (0.018) | 1.0 | 4.96 | 7.48 |
| | | | | | Total= | 66.27 | 99.91 |

**Impact HYDRO-1: The project could violate water quality standards or waste discharge requirements. (Less than Significant)**

The proposed project does not propose to add residential or commercial structures, roadways or driveways, or other forms of impervious surfaces to the Reserve lands, nor would it result in an increase in the existing levels of auto use. Thus, no increases in the contaminant loading of site stormwater by petrochemical residues, heavy metals, pesticides, nutrients or other typical urban pollutants would occur as the result of proposed project implementation. The proposed project will likely include some targeted use of herbicides on the USEPA's list of approved herbicides. As noted above under Water Quality and Regulatory Setting, Central San Francisco Bay is currently designated by the SFRWQCB as impaired for pesticides chlordane, DDT, and dieldrin, and for dioxins, mercury (dissolved and sediment), furan compounds, exotic species, PCBs and selenium. In addition, Total Maximum Daily Load objectives now apply for mercury and urban creeks pesticide toxicity. Similarly, the nearshore Pacific Ocean adjacent to San Francisco is impaired for bacteria. However, there is no established impairment for herbicide listed for either receiving water. Therefore, none of the established water quality standards for SF Bay or the nearshore Pacific Ocean would be exceeded.

All stormwater runoff exiting the project area eventually enters the CSS en route to either the Southeast WTP or the Oceanside WTP. Waste Discharge Requirements (WDRs) adopted for these treatment plants include influent monitoring requirements and sampling protocols for 5-day Biological Oxygen Demand ($BOD_5$), Total Suspended Solids (TSS) and pH. Measured constituents for TSS include soil particles, as well as sanitary sewage, dissolved solids (e.g. salts, sulfides) and other particulates. The minor increase in sediment yield predicted for the projected

tree thinning and worst case (concurrent 90%) cutting of non-native brush would not have a significant impact on the turbidity or TSS of wet weather flows conveyed by the City CSS which typically total 500 million gallons per day (mgd). Furthermore, the more serious contaminants that are monitored in WTP influent, such as ammonia, oil and grease, pesticides, PCBs, PAHs and other selected inorganic and organic contaminants would be absent in project area stormwater runoff. Thus, none of these contaminants would be absorbed onto site sediment, and post-project site stormwater would not violate any WDRs.

**Mitigation:** None required.

**Impact HYDRO-2: The project could substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion on- or off-site. (Less than Significant)**

Implementation of the suite of proposed vegetation management actions would have no effect on existing site drainage patterns or the course of any drainageways, including Woodland Creek. No new culverts would be installed, nor would site runoff be concentrated by constructed diversions or other means. Therefore, no substantial erosion or siltation on- or off-site would result from any such modifications to the existing drainage characteristics. The EIR sediment yield assessment indicated that a minor increase in the event-based sediment yields from site watersheds could occur under worst-case management conditions due to a short term disturbance of the dense woodland and brush that currently covers the site. For a discussion of the potentially significant impact of this short term disturbance on water quality, see the Impact HYDRO-10 below.

**Mitigation:** None required.

**Impact HYDRO-3: The project could substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level. (Less than Significant)**

There are no proven or established groundwater supplies within the project area, nor would the proposed project introduce any impervious surfaces or significantly reduce rainfall infiltration rates or groundwater recharge. Thus, the proposed project would have no impact on groundwater supplies or groundwater recharge rates or volumes.

**Mitigation:** None required.

**Impact HYDRO-4: The project could substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site. (Less than Significant)**

The proposed project will not result in the imposition of any new impervious surfaces, nor will it result in significant increases in project area stormwater runoff or peak flow rates, as

demonstrated in the EIR's Peak Flow and Runoff Volume Assessment. Under a worst-case thinning and cutting regimen, some increase in site sediment yield could occur, however, unless sediment conveyed in site runoff were accompanied by substantial organic debris, it is not likely that roadway flooding would be triggered by obstructed culvert inlets. More than likely, the reduction in eucalyptus density throughout the Reserve would reduce the volume of slash delivered downslope to such roadway culverts, which is likely the most common cause of culvert obstruction. Thus, the proposed project would not alter the drainage pattern in the site's watersheds, nor would it increase the rate or amount of surface runoff. Consequently, the risk of on-site or off-site flooding would likely be reduced by project implementation.

**Mitigation:** None required.

**Impact HYDRO-5: The project could create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems. (Less than Significant)**

The peak flow and runoff volume computations prepared by the EIR hydrologist indicated the proposed thinning of the tree canopy and cutting of existing non-native vines and brush will have a slightly beneficial impact relative to the existing site condition. This is due to the less efficient runoff production from mixed brush and grass with substantial surface mulch in areas where the existing woodland is thinned. Therefore, the proposed project would have a less-than-significant impact on on-site roadway culvert capacities, Woodland Creek or the receiving storm drain systems maintained by the City of San Francisco.

**Mitigation:** None required.

**Impact HYDRO-6: The project could require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects. (Less than Significant)**

Since peak flow rates and runoff volumes would likely decrease under post-project conditions, there would be no requirement to construct new stormwater drainage facilities or to expand existing facilities. Thus, the proposed project would not cause any significant environmental effects.

**Mitigation:** None required.

**Impact HYDRO-7: The project could place housing within a 100-year flood hazard area as mapped on a Federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map; or place within a 100-year flood hazard area structures that would impede or redirect flood flows. (Less than Significant)**

No housing or structures would be built as part of the proposed project. FEMA or other entities have not produced a flood hazard map for the project area, and there is no indication of a flood hazard existing within or adjoining the project area.

**Mitigation:** None required.

**Impact HYDRO-8: The project could expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam. (Less than Significant)**

The proposed project will not result in the imposition of any new impervious surfaces, nor will it result in significant increases in project area stormwater runoff or peak flow rates. Project watersheds contain only one defined stream channel (Woodland Creek) and no upstream levees or dams.

**Mitigation:** None required.

**Impact HYDRO-9: The project could result in inundation by seiche, tsunami, or mudflow. (Less than Significant)**

The lowest elevation within the project area is approximately 450 ft. NAVD88 and thus is far above the zone of inundation by a seiche on SF Bay or a tsunami, which even at a 500-yr. recurrence interval is predicted at approximately 16 feet NGVD, or 18.5 ft. NAVD88.[20] Since no buildings will be constructed as part of the proposed project, and the proposed project will not affect either the direction or concentration of site surface drainage, there will be no risk of inundation of structures by mudflows. For a discussion of on-site landslide potential, see Section 4.5 Geology and Soils.

**Mitigation:** None required.

**Impact HYDRO-10: The project could substantially degrade water quality. (Less than Significant with Mitigation)**

Project implementation would utilize herbicides to control non-native and invasive species within the Reserve lands. The rates of both tree thinning and brush and vine cutting are as yet undetermined, but brush removal could affect as much as 90 percent of the non-native plant communities during the initial implementation phase. While the EIR peak flow and runoff volume assessment indicated that the proposed project would produce slight reductions in both of these parameters relative to the existing site condition, the EIR sediment yield assessment estimated minor increases in site sediment yields for the post-project condition. The project VMP and the project biological resources report prescribe erosion control Best Management Practices (BMPs) which will be applied during and after the proposed treatments to maximize the on-site retention of sediment and to protect water quality. Other than filing the required Notice of Intent along with a Stormwater Pollution Prevention Plan and related BMP documentation to State Water Resources Control Board, no additional mitigation measures will be required.

---

[20] *Type 16 Flood Insurance Study: Tsunami Predictions for Monterey and San Francisco Bays and Puget Sound,* Techncial Report H-75-17, Hydraulics Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS, November 1975. Figure cited is 500-yr. tsunami runup prediction at the Golden Gate. Note that 0 ft. NGVD= -2.5 ft. NAVD88 at San Francisco.

The proposed use of EPA-approved herbicides for invasive plant control would increase the concentration of herbicide constituent chemicals in site stormwater. The level of risk to human, vegetal and animal health due to herbicide application would vary, depending on the precautions taken by workers; on the herbicide used, its concentration and timing of application; on the length and manner of exposure; and on the extent herbicide degradation at the point of exposure. Even under worst-case spills of herbicide within the Reserve lands, natural dilution with off-site CSS flows would reduce herbicide concentrations to non-toxic levels by the time such flows were treated and/or discharged to the Pacific Ocean or SF Bay from either the Oceanside WTP or the Southeast WTP. Given the uncertainty in the areal coverage and the rate of implementation of the proposed project's proposed vegetation control measures, as well as the possibility of accidental spills of herbicides, the application of herbicides to portions of the managed lands constitutes a potentially significant impact to water quality.

As noted above, the proposed project will not introduce comparable amounts of water quality contaminants associated with typical urbanization projects. An estimated maximum increase in site sediment yields of approximately 50 percent was computed by the present EIR sediment yield assessment. Increases in unmitigated, post-project sediment yield for typical residential urbanization projects involving mass grading of hillsides and the installation of storm drain systems may reach 200 to 300 percent. While the computed increase in project area sediment yield under the forecasted management techniques is relatively minor, use of cutting machines on steeper portions of the site watersheds, or incursion of machines into sensitive areas around Woodland Creek could increase erosion and downstream sedimentation in the absence of appropriately installed BMPs

The Reserve management plan[21] referenced the following typical BMPs applied to similar vegetation management plans, some of which were also cited as recommendations in the project biological resources report[22]:

- Application of wood chips or other mulch material to disturbed or bared soil surfaces.
- Installation of straw wattles, straw bales, silt fences or similar devices along the downslope site perimeter to filter site runoff.

As of Sept. 2011, the SF Bay Regional Water Quality Control Board (RWQCB) requires that Stormwater Pollution Prevention Plans (SWPPPs) be prepared by a qualified stormwater developer (QSD) and that their installation and functioning be supervised by a either a QSD or a qualified stormwater practitioner (QSP), both of which are now certified by the RWQCB. The established oversight process also ensures that the project owner is held responsible for the proper installation and maintenance of BMPs. Filing of the NOI, SWPPP and related documentation with the State Water Resources Control Board (SWRCB) and the mandated retention of a RWQCB-certified QSD to prepare the SWPPP and a QSD/QSP to oversee BMP

[21] *Mount Sutro Open Space Reserve Management Plan* (UCSF, et al. 2001)

[22] *Biological Resources Report Mount Sutro Open Space Reserve, San Francisco, California*, prepared by LSA, September 2011.

installation and maintenance in the field would reduce any potential project impact on erosion and downstream sedimentation to a less than significant level.

***EIR Herbicide Risk Assessment***

Approved herbicides may be applied to portions of the managed lands to eliminate non-native, invasive species, as well as some poison oak (a native) immediately adjacent to trail segments used by the public, and/or to prevent re-sprouting of these target species. Accordingly, an herbicide risk assessment analysis and report were prepared as an adjunct to the EIR water quality assessment.[23] The assessment report assumed compliance with the guidelines for herbicide use set forth in the project VMP. It includes a discussion of the fate and transport of applied herbicides in surface and groundwaters, as well as the processes of vaporization and wind-induced drift, and soil and wind erosion. Herbicide constituents can adsorb onto sediment particles, which can be mobilized and transported by raindrop impact and surface runoff during rainstorms. Contaminants can also be transferred in solute form in surface runoff. The same constituents may also enter the groundwater system through the intervening physical processes of soil infiltration and deep percolation. The likelihood of this transfer is reduced where soils are fine-grained, which are less permeable than coarser soils, and where surface runoff must travel through vegetated or mulched areas. Chemical constituents are also subject to degradation in the environment by microbial activity, photolysis, hydrolysis and other chemical reactions.

Based on an extensive review of EPA-approved herbicides that are both appropriate for control of the targeted species, the assessment analyzed two herbicides for proposed project use: Aquamaster and Garlon 4 Ultra. Aquamaster (active ingredient is glyphosate) would potentially be applied in both foliar and cut-stump treatments and Garlon 4 Ultra (active ingredient is triclopyr butoxyethyl ester) would potentially be applied only for cut-stump treatments. Two adjuvants were also assessed to increase herbicide effectiveness and application accuracy: a surfactant (Competitor) and a dye (Blazon).

The EIR hazardous risk assessment assumed four treatment scenarios for the approximately 48 acres of Reserve areas deemed accessible for the field application of herbicides. Roughly 14 to 15 acres of the 61-acre Reserve were excluded due to excessive steepness (slopes > 30%) and/or limited accessibility. The four treatment scenarios were:

1) **Maximum treatment scenario:** All accessible acres (48 total) treated at the maximum application rate of 4 lbs a.e./acre;
2) **Half-treatment scenario:** Half the accessible acres (24) treated at the maximum application rate or all of the acres treated at 2 lbs a.e./acre; and
3) **Quarter-treatment scenario:** One-quarter (12) of the accessible acres treated at the maximum application rate or all of the acres treated at 1 lb a.e./acre.

[23] *University of California San Francisco (UCSF) Mount Sutro Herbicide Risk Assessment, Final, April 25, 2012*, prepared by Pesticide Research Institute, Berkeley, CA.

4) **Demonstration project scenario:** Treatment of Demonstration project areas #1 (one acre) and #4 (two acres) at the maximum application rate of 4 lbs a.e./acre.

The assessment assumed the application of herbicide products diluted to 5%, 20%, and 50% product by volume for cut-stump treatment solutions, and 1%, 2%, and 5% by volume for foliar treatment solutions. It used toxicity data from government and research agencies which was presented in terms of either Reference Doses (RfD, for human contact) or Toxicity Reference Values (TRVs), for assessment of terrestrial and aquatic wildlife impacts. Specific exposures of concern were defined as those that would result in a "Hazard Quotient" (HQ) of greater than 0.1, i.e. 10% of the listed RfD or TRV values. The HQ is defined as the ratio of the estimated exposure to the TRV, which for humans is the same as the RfD. The citing of HQs between 0.1 and 1.0 as exposures of concern allowed for variances in responses of particular species to the probable range of applied herbicide concentrations.

Results for the risk assessment under the most likely ("Central") estimated chemical dosages for a selection of key treatment scenarios are presented in Section 4.8, Hazards – Herbicide Use in this EIR, and in the Herbicide Risk Assessment report (Tables 1-2, 1-3 and 1-4) in Appendix G. Table 1-2 describes the estimated exposures and risk levels for herbicide applicators and the general public. It includes Central HQ estimates for both the Upper and Lower proposed herbicide application rates of 4 lbs/ac and 1 lb/ac, respectively. Tables 1-3 and 1-4 present the Central HQ estimates for terrestrial wildlife and for aquatic wildlife and plants, respectively.

The highest exposures of concern (i.e., highest Hazard Quotients) for human contact were associated with the improbable scenarios of drinking water from puddles, pools or Woodland Creek after a spill of either Aquamaster or Garlon 4 Ultra. Even for a one gallon spill directly to Woodland Creek, the HQ for directly ingested water would range from 1.6 (for 2% foliar solution) to 702 (for 20% cut-stump solution), with the upper end of the range applying to ingestion of Garlon 4 Ultra solutions by women. The threshold for tolerance of chemical exposure for women of childbearing age is significantly lower, and this is reflected in the upper limit cited for women in the table. For workers, exposures of concern could occur from accidental spills of triclopyr (Garlon 4 Ultra) solutions onto skin, a more likely occurrence based on studies of field workers applying pesticides. A similar worker exposure to Aquamaster did not result in an exposure of concern, due to glyphosate's lower toxicity. For terrestrial wildlife, the estimated exposures to both glyphosate and triclopyr that exceeded a dose of concern involved drinking contaminated water from puddles, pools or Woodland Creek after an herbicide spill. These exposures were considered improbable, as long as the project guidelines for transport, storage, handling and use are followed.

For aquatic wildlife, amphibians that use seasonal pools and puddles for breeding habitat would be most at risk from herbicide spills abetted by active overland flow for both glyphosate and triclopyr-based formulations, Implementation of the maximum treatment scenario in the Woodland Creek watershed could also result in exposures of concern for wildlife if triclopyr-based herbicides were applied, and surface runoff and dissolved herbicide were discharged to Woodland Creek during the winter rainy season following the application. The risk assessment

noted that triclopyr poses higher risks to aquatic life than glyphosate because of its higher toxicity.

The effect of project herbicide runoff on Pacific Ocean and San Francisco Bay following any of the potential treatment scenarios was determined by computing the dilution and degradation rates associated with storm-generated CSS inflows reaching the Oceanside WTP. The results for the Oceanside plant were presented in Chapter 1 as a worst-case scenario, since the portions of the project watersheds draining west toward that plant were much higher than those draining toward the Southeast WTP.[24] Thus, the computed concentrations would be greater than those entering the the Southeast WTP under the same project treatments. As shown in Table 1-4, project-induced HQs for CSS inflows to the Oceanside WTP under either glyphosate or triclopyr applications and Maximum or Demonstration treatment scenarios would be 0.099 or less, and thus would fall below the level of concern for aquatic plants and wildlife.

To reduce the impact on water quality degradation, the proposed project has specified the following general guidelines for use of herbicides as part of the vegetation management program[25]:

1. Limit when herbicides would be used: Herbicides will be used for controlling eucalyptus, ivy, ehrharta, poison oak, and other undesirable non-native vegetation where other techniques are known to be ineffective or prohibitively expensive.

2. Use least toxic herbicide: Glyphosate herbicides that contain no known toxic inerts will be used for shrubs and vines. Aquamaster® will be used for vines, shrubs, and trees. Garlon 4 Ultra will be used for cut stump treatments for trees. Competitor® is a surfactant that would be mixed with Aquamaster®.

3. Integrated Pest Management (IPM) Approach: Cutting/mowing will be used to eradicate target plants prior to herbicide treatments to minimize the amount of herbicide used.

4. Allowed herbicides, application rates and treatment targets: The following list describes the target usage and maximum application rates for proposed herbicides, surfactants and dyes when initially applied. It is expected that in many cases, the amount used would be significantly less than the amounts shown below. Also, the amount will be substantially less during the five-year retreatment periods—just enough to treat any new sprouts or survivors, which are expected to decrease substantially with each year of retreatment. Details of application rates are provided below.

   **Aquamaster®** (53.8% Glyphosate, isopropylamine salt)
   Target usage:
   - Understory shrubs and vines 1-5 quarts per acre

[24] Results from both treatment plants were provided in the detailed risk assessment.
[25] See Pesticide Research Institute risk assessment report, Chapter 2.

(1.25 to 4 lb a.i./acre)[26]

**Garlon 4 Ultra®** (60.45% Triclopyr, butoxy ethyl ester)
Target usage:

| | |
|---|---|
| • Cut stumps of trees | 1 to 4 quarts per acre (1-4 lb a.i./acre) |

**Competitor®** (ethyl oleate, sorbitan alkylpolyethoxlate ester, dialkyl polyoxyethylene glycol)
Target usage:

| | |
|---|---|
| • Surfactant for use with both herbicides | not more than 8 quarts per acre (14.8 lb a.i./acre) |

**Blazon:**
Target usage:

| | |
|---|---|
| • Dye for use with both herbicides | 4 ounces per acre (0.28 lb a.i./acre) |

***Application Methods***

Herbicides would be spot applied by a wick, sponge, squirt bottle or directed-spray applicator to cut stems or, for certain species such as Ehrharta, to foliage. UCSF has made a commitment to not conduct broadcast or widespread vegetation spraying.

***Exclusion Areas***

Herbicides would not be applied within 100 feet of Christopher and Crestmont Streets or the backyards along Edgewood Avenue. Garlon would not be applied within 50 feet of a stream. Herbicides would also not be applied to any area where no vegetation is removed. These areas, which are generally too steep and inaccessible for equipment, consist of pockets of forest along the western and eastern edges that are estimated to compose about 10-15% of the Reserve. For purposes of the risk assessment, it is assumed that 48 acres of the total 61 acres would be treated with herbicides.

In addition, the following specific guidelines for herbicide application were developed for the proposed project. The application of herbicides would comply with all project guidelines set forth above, as well as the following specific Herbicide Use Restrictions:

1. Concentrated pesticide products are to be transported in a spill-proof, sealed container above and beyond the product container. The volume of concentrated product being transported on the site at any given time should be limited to less than 20 gallons.
2. All trailheads and other access points leading to the treatment area will be closed during the day of application and posted prior to treatment in order to minimize exposures to the general public.

[26] The unit descriptor a.i. is an abbreviation for active ingredient.

3. Blazon blue dye shall be used with all treatments to clearly delineate the treated areas, and the signs shall explain that contact with cut stumps and vegetation with visible dye should be avoided.
4. Treated areas will be posted for two weeks after the application to inform the general public of where applications have been conducted.
5. No applications will be conducted on weekends to minimize exposures to the general public.
6. All applications will be done by licensed applicators.
7. No applications should be conducted when wind speeds exceed the pesticide label-designated wind speeds (normally less than 10 mph) or in locations where prevailing winds might carry spray drift onto private property.
8. Any herbicide treatments will be conducted no earlier than June 1 to minimize the impact on nesting birds and no later than December 1, to avoid applications during the peak of the rainy season.
9. Within 30 feet (or within a feasible distance) of all roads and trails, areas to be treated should be mowed or pruned to knee height (approximately 2 feet) or lower prior to treatment to minimize exposure to the public and workers from contacting treated vegetation and reducing the probability of spraying honeybees and small mammals. No foliar applications should be made to vegetation above approximately shoulder height.
10. Applicators should spray in a downward direction to prevent spray drift from above.
11. Applicators will wear gloves, protective footwear, goggles, and coveralls. An eyewash bottle and extra pairs of clean gloves, soap, and water will be available in each vehicle for washing if workers are exposed.
12. Mixer-loaders will wear gloves, rubber boots, goggles, coveralls, and a protective apron.
13. All mixing and loading will be done in a manner to contain any spills that might occur during transfers and will not be done near a water body.
14. Spill cleanup materials will be available in all vehicles used for herbicide applications. Any vehicle transporting herbicide shall carry absorbent material on-board at all times in a quantity sufficient to contain a spill of the entire volume of herbicide being transported on the vehicle.
15. If workers accidentally spill herbicide on themselves, they will be required to wash the affected area as soon as possible.

The following triclopyr-specific (Garlon 4) guidelines will also be employed. Generally speaking, triclopyr application leads to higher human and wildlife doses due to its higher dermal permeability. The following mitigations are designed to minimize hazardous dermal exposures to triclopyr:

A. No applications of Garlon will be conducted within 50 feet of a perennial or intermittent stream.
B. Two layers of gloves will be required for workers.
C. Backpack applicators that incorporate some form of physical separation between the backpack sprayer and the applicator are strongly recommended to prevent spills onto the applicator from a leaking backpack sprayer.

**Mitigation Measure HYDRO-10:** To further assure project impacts are less than significant, UCSF shall comply with the following measures:

- Minimize the use of triclopyr-based herbicides whenever possible and utilize only glyphosate-based herbicides within site Subwatersheds 2 and 3 (Figure 2). Subwatershed 2 surface runoff directly enters adjoining residential properties to the east of the site. Subwatershed 3 drains to Woodland Creek where the Central HQs for accidental spills and overland runoff have the highest potential for exceeding doses of concern for humans and aquatic wildlife. The herbicide risk assessment cites evidence in the research literature that glyphosate-based herbicides appear to be equally effective in cut-stump treatments if stumps are treated immediately after cutting.

- Use the lowest concentrations of herbicide possible for cut-stump treatments. The risk assessment noted that efficacy studies indicate that concentrations of glyphosate and triclopyr products as low as five percent can be as effective as 50–100 percent solutions if stumps are treated immediately after cutting. Use of a more dilute herbicide solution will also allow for treatment of more trees per acre, thereby avoiding limitations in the number of trees that can be treated.

- Cut vegetation prior to treatment to minimize the potential for direct sprays to wildlife and contact with treated vegetation for workers, the general public, and terrestrial wildlife.

- Apply herbicides as early as possible in the summer to allow time for degradation to occur prior to the rainy season when possible.

- Change spill-handling procedures to require thorough cleanup of all spills to puddles and to the land.

- To the extent feasible, fill topographic depressions with soil where puddles might form near heavily treated areas in order to reduce the probability that overland flow from treated sites would contaminate areas that could be used as amphibian breeding habitat.

- Create a 25-ft. herbicide- application setback zone along Woodland Creek to provide a water quality buffer zone and to minimize opportunities for direct entry of accidentally spilled herbicides to the Creek.

- Maintain an on-site environmental monitor with knowledge of and experience in safety and cleanup procedures with respect to herbicide application to monitor the contractor retained to implement this portion of the management plan. Ensure that the on-site monitor is fully conversant with the project guidelines for herbicide handling, storage and cleanup, including those cited as additional mitigation measures herein.

**Significance after Mitigation:** Implementation of the measure cited above under Mitigation HYDRO-1 and the guidelines previously proposed for the project by UCSF would reduce potential project water quality impacts to a less than significant level.

**Responsibility and Monitoring:** Since the expected the cutting of site vegetation and thinned trees will involve the use of a Brontosaurus-type mastication machine, there will be some disturbance of the soil surface within the treatment areas. Thus, the applicant would be responsible for preparing the project SWPPP, the NOI and the NPDES Permit application. The State Water Resources Control Board would be responsible for reviewing the NOI and the NPDES permit application, including the project SWPPP. The applicant would be responsible for retaining an environmental monitor to oversee herbicide application, as well as a QSD/QSP to prepare and implement the BMPs incorporated into the SWPPP.

**Impact HYDRO-11: The project could result in a substantial adverse cumulative effect with regard to hydrology and water quality. (Less than Significant)**

As part of the San Francisco Significant Natural Resource Areas Management Plan (SNRAMP), the City of San Francisco proposes to conduct vegetation management activities, including the select removal of invasive plants and trees such as eucalyptus, within the Interior Greenbelt area directly adjacent to the Reserve. SNRAMP vegetation management activities in the Interior Greenbelt will be selective and incrementally applied, and will be subject to erosion and stormwater quality control mitigation measures similar in scope and intensity to those recommended in this EIR.[27] Thus, the project would not result in substantial adverse cumulative impacts with regard to peak flow rates and erosion and sediment yield, when considered in combination with the proposed project. SNRAMP herbicide use within managed natural areas will be restricted and subject to the City Recreation and Parks Department (SFRPD) Integrated Pest Management (IPM) Program and the City's Integrated Pest Management Ordinance. Therefore, cumulative impacts would likewise not be significant with regard to water quality impacts from herbicide use (see Section 4.8 for detailed analyses).

**Mitigation:** None required.

## 4.9.6 REFERENCES

LSA, *Biological Resources Report Mount Sutro Open Space Reserve, San Francisco, California*, September 2011.

Rutherford & Chekene, *Slope Stability Risk Assessment, University of California San Francisco, San Francisco, California*, 25 August 2006.

[27] Natural Areas Management Plan Draft EIR, Section V.H *Hydrology and Water Quality*, Case No. 2005, 1912E. Prepared by Tetra Tech for the City of San Francisco Recreation and Parks Department, August 2011.

San Francisco Bay Regional Water Quality Control Board (RWQCB), *Water Quality Control Plan--San Francisco Bay (Region 2)*, adopted June 1995, with most recent Plan amendments adopted in 2004.

State of California Water Resources Control Board and US EPA, *California Ocean Plan: Water Quality Control Plan- Ocean Waters of California*, latest amendments adopted Feb. 2006. Additional 2011 amendments to the 2006 Ocean Plan are currently undergoing legal and environmental review.

USDA, Natural Resources Conservation Service, Conservation Engineering Division, *Urban Hydrology for Small Watersheds: TR-55*, Technical Release 55, June 1986.

# 4.10 NOISE

## 4.10.1 INTRODUCTION

This section discusses the existing noise environment in the project vicinity, the regulatory framework for regulation of noise, and analyzes the potential for the proposed project to affect the existing ambient noise environment. The impacts associated with the proposed project are compared with the thresholds of significance adopted by the California Environmental Quality Act (CEQA).

Comments related to noise received during the Initial Study/EIR scoping process included concerns about the following:

- Increased noise exposure to surrounding residents by removing the noise buffer that vegetation provides

## 4.10.2 ENVIRONMENTAL SETTING

### Background Information on Noise

Noise is usually defined as unwanted sound and can be an undesirable by-product of society's normal day-to-day activities. Sound becomes unwanted when it interferes with normal activities, causes actual physical harm, or has an adverse effect on health. The definition of noise as unwanted sound implies that it has an adverse effect or causes a substantial annoyance to people and their environment.

Sound pressure level alone is not a reliable indicator of loudness because the human ear does not respond uniformly to sounds at all frequencies. For example, it is less sensitive to low and high frequencies than to the medium frequencies that more closely correspond to human speech. In response to the human ear's sensitivity to different frequencies or lack thereof, the A-weighted noise level, referenced in units of dB(A), was developed to better correspond with peoples' subjective judgment of sound levels. In general, changes in a community noise level of less than 3 dB(A) are not typically noticed by the human ear (FHA 1980). Changes from 3 to 5 dB(A) may be noticed by some individuals who are extremely sensitive to changes in noise. An increase greater than 5 dB(A) is readily noticeable, while the human ear perceives a 10 dB(A) increase in sound level to be a doubling of sound volume. A doubling of sound energy results in a 3 dB increase in sound, which means that a doubling of sound wave energy (e.g., doubling the volume of traffic on a roadway) would result in a barely perceptible change in sound level. Common noise levels associated with certain activities are shown on Figure 4.10-1, Common Noise Levels.

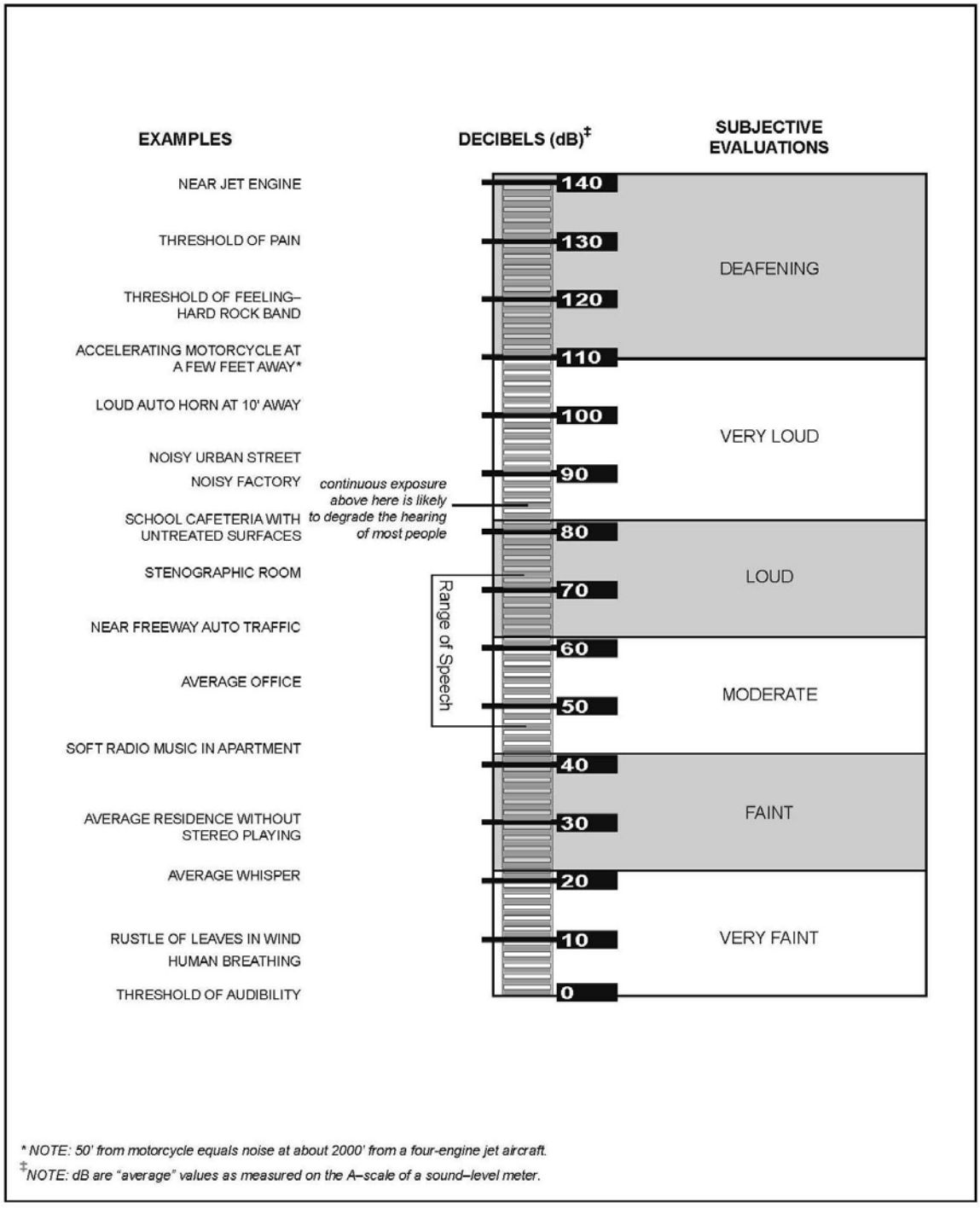



**Figure 4.10-1**
Common Noise Levels

Noise sources occur in two forms: (1) point sources, such as stationary equipment or individual motor vehicles; and (2) line sources, such as a roadway with a large number of mobile point sources (motor vehicles). Sound generated by a stationary point source typically diminishes (attenuates) at a rate of 6 dB(A) for each doubling of distance from the source to the receptor at acoustically "hard" sites, and at a rate of 7.5 dB(A) at acoustically "soft" sites (FHA 1980). For example, a 60 dB(A) noise level measured at 50 feet from a point source at an acoustically hard site would be 54 dB(A) at 100 feet from the source and it would be 48 dB(A) at 200 feet from the source. Sound generated by a line source typically attenuates at a rate of 3 dB(A) and 4.6 dB(A) per doubling of distance from the source to the receptor for hard and soft sites, respectively (FHA 1980).

Environmental noise fluctuates in intensity over time, and several descriptors of time-averaged noise level are in use. The three most commonly used descriptors are $L_{eq}$, $L_{dn}$, and CNEL. $L_{eq}$, the energy equivalent noise level, is a measure of the average energy content (intensity) of noise over any given period of time. $L_{dn}$, the day-night average noise level, is the 24-hour average of the noise intensity, with a 10-dB(A) "penalty" added for nighttime noise (10 PM to 7 AM) to account for the greater sensitivity to noise during this period. CNEL, the community equivalent noise level, is similar to $L_{dn}$, but adds a 5-dB(A) penalty to evening noise (7 PM to 10 PM).

## Effects of Noise on People

Sound becomes unwanted when it interferes with normal activities, when it causes actual physical harm, or when it has adverse effects on health. The effects of noise on people can be placed into three categories:

- Subjective effects of annoyance, nuisance, dissatisfaction
- Interference with activities such as speech, sleep, and learning
- Physiological effects such as hearing loss

Environmental noise typically produces effects in the first two categories, while workers in industrial plants may experience noise in the third category. There is no completely satisfactory way to measure the subjective effects of noise, or the corresponding reactions. A wide variation in thresholds of annoyance exists in individuals, and different tolerances to noise tend to develop based on a person's past experiences with noise.

Thus, an important way of predicting human reaction to a new noise is to compare the existing environment to which one has adapted with the so-called "ambient noise" level. In general, the more a new noise exceeds the previously existing ambient noise level, the less acceptable the new noise will be judged by those hearing it. With regard to increases in A-weighted noise level, the following relationships occur:

- Except in controlled laboratory experiments, a change of 1 dBA cannot be perceived.
- Outside of the laboratory, a 3-dBA change (which can result from combining two equal noise sources) is considered a just-perceivable difference.
- A change in level of at least 5 dBA is required before any noticeable change in human response would be expected.
- A 10-dBA change is subjectively heard as approximately a doubling in loudness, and such an increase can cause an adverse response.

These relationships occur in part because of the logarithmic nature of sound, the decibel scale that describes that nature and the nonlinear fashion in which the human ear perceives sound.[1]

## Noise Attenuation

Stationary point sources of noise, including stationary mobile sources such as idling vehicles, attenuate (lessen) at a rate between 6 dB for hard sites and 7.5 dB for soft sites for each doubling of distance from the reference measurement. Hard sites are those with a sound-reflective surface, such as parking lots or smooth bodies of water, between the source and the receiver. No added ground attenuation is assumed for hard sites, so the changes in noise levels over distance (drop-off rate) is simply the result of the geometric spreading of the noise from the source. Soft sites have an absorptive ground surface such as soft dirt, grass, or scattered bushes and trees, so in addition to geometric spreading, an additional ground attenuation value of 1.5 dB (per doubling of distance) is normally assumed for soft sites. Widely distributed noise sources, such as within a large industrial facility spread over many acres or along a street with moving vehicles (a "line" source), would typically attenuate at a lower rate, approximately 3 to 4.5 dB per doubling of distance from the source (also dependent upon environmental conditions). Noise from large construction sites would have characteristics of both "point" and "line" sources, so attenuation would range between 3.0 and 7.5 dB per doubling of distance.

At a minimum, exterior noise levels are reduced by 10 to 15 dB (Single-Event Noise Exposure Level or SENEL) inside residences if windows are open. Noise reduction is much greater if windows are closed – typically 15 to 20 dB.[2]

## Project Site and Surrounding Land Uses

The Mount Sutro Open Space Reserve is bordered by residential uses to the east, west, and south. A portion of Sutro Forest to the east of the Reserve is within the Interior Greenbelt, owned and managed by the City of San Francisco. Nestled within (but not a part of) the Reserve is the UCSF Aldea housing complex, the Chancellor's residence, several small campus structures – the Woods, Surge, and Environmental Health and Safety buildings -- and the Surge and Woods

[1] Caltrans, Traffic Noise Analysis Protocol for New Highway Construction and Reconstruction Projects, October 1998.

[2] HMMH, *Helicopter Noise Analysis for UCSF Mission Bay Hospital Site*, March 2008, p. 21.

parking lots. To the north of the Reserve is the main developed portion of the campus, which includes the UCSF Moffitt and Long hospitals, medical research and instruction buildings, a power plant, the student union, academic and administrative offices, the campus library, various support functions, and parking and loading facilities. The area bustles with activity from campus life, particularly the portion along or adjacent to Parnassus Avenue, the main public street that the campus straddles. The primary sources of noise in the area stem from mechanical equipment associated with campus building operations, and a wide array of other activities associated with the campus such as maintenance and renovation activities, truck deliveries, car doors shutting, and people walking or talking. Mobile sources of noise in the project vicinity include traffic noise along Parnassus Avenue and adjacent streets.

Information on ambient noise levels at sites on and around the Parnassus Heights campus site is available from a variety of past studies that have been prepared over the years for various purposes, using various noise metrics. Ambient noise measurements taken in 1994 indicated daytime (measured from 10 a.m. to 5 p.m.) $L_{eq}$ noise levels on Edgewood Avenue ranged from 45 to 49 dBA, and slightly higher on Farnsworth Lane from 49 to 52 dBA.[3] Noise levels on Parnassus Avenue adjacent to the campus ranged from 56 to 61 dBA. Nighttime noise levels (measured from 12 a.m. to 6 a.m.) on Edgewood Avenue ranged from 37 to 40 dBA; on Farnsworth Lane from 41 to 45 dBA; on Parnassus Avenue from 42 to 52 dBA; and on 5th Avenue from 36 to 41 dBA.

While the above noise measurements were taken in 1994, it is not expected that traffic or other noise sources audible on the streets adjacent to the campus have changed substantially such that the noise levels would be vastly different today. According to the City and County of San Francisco Draft EIR for the San Francisco Overlook project, a proposed private residential development near the western side of the Reserve along Crestmont Drive, noise levels measured in 2005 on that site indicate a noise level of 49 dBA $L_{eq}$.[4] Noise levels could be somewhat higher on more heavily trafficked streets in the vicinity.

The City and County of San Francisco Department of Public Health publishes and maintains a map of background noise levels in San Francisco, which is then incorporated into the Environmental Protection Element of the San Francisco General Plan.[5] The 2009 map, the most recent available, provides estimates of noise levels on public streets based on traffic modeling, using the $L_{dn}$ noise descriptor. The map indicates noise levels are about 70 dBA or greater on Parnassus Avenue, 60 to 65 dBA on 5th Avenue, and 50 to 55 dBA or lower on Edgewood Avenue and Farnsworth Lane. These noise level estimates using the $L_{dn}$ noise descriptor are not directly comparable to the measured noise levels using the $L_{eq}$ noise descriptor noted in the paragraphs above.

---

[3] Bechtel Corporation, Preliminary Noise Plan for UCSF Parnassus Campus, Draft December 6, 1994.

[4] City and County of San Francisco Planning Department, Draft Environmental Impact Report for the San Francisco Overlook Development Residential Project, May 2, 2012.

[5] City and County of San Francisco, Background Noise Levels, 2009 http://www.sf-planning.org/ftp/general_plan/images/I6.environmental/ENV_Map1_Background_Noise%20Levels.pdf

In connection with The Regents' approval in 1994 of the Parnassus Heights Central Utilities Plant, UCSF began investigating potential modifications of UCSF noise sources at Parnassus Heights -- in particular rooftop mechanical equipment, the major operational noise source on the campus -- in an attempt to meet limits established by the San Francisco Noise Ordinance at surrounding residential property lines. A noise attenuation study was prepared in 1998 that identified ways to mitigate noise impacts of campus rooftop mechanical equipment.[6] The study included performance standards to meet the noise limits established by the San Francisco Noise Ordinance, which at that time was 50 dBA during the night (10 p.m. to 7 a.m.) and 55 dBA during the day (7 a.m. to 10 p.m.) at residential property lines closest to the Parnassus Heights site boundary.[7] The goal was to meet these Noise Ordinance standards over time as campus rooftop mechanical equipment is upgraded and replaced. Existing noise measurements taken at the time of the study included a location in the Reserve, at the rear of the Edgewood Avenue residences, where ambient noise was dominated by mechanical equipment on the campus, including the then-existing central utilities plant. Hourly average noise levels at that location ranged from 57 to 60 dBA over a continuous period of about four days, which exceeded the 50/55 dBA goal.

In 2010, an ambient noise study was again undertaken to determine the effectiveness of noise attenuation measures taken to date.[8] Noise measurements were taken within the Reserve at the rear of the Edgewood Avenue residences, and within the nearby Surge parking lot, where the noise from rooftop mechanical equipment and the power plant was most dominant. It was found that modifications to existing equipment and new equipment installed since the 1998 noise study have further reduced the overall noise levels measured, ranging from about 48 to 59 dBA over a continuous period of one week. While in 2010 the campus still did not meet the 50/55 dBA goal in all instances where noise was measured, overall noise levels were determined to be less than in 1998, and are expected to continue their downward trajectory as advances are made in noise attenuation technology and as more mechanical equipment is upgraded and replaced.

## 4.10.3 REGULATORY CONSIDERATIONS

UCSF is constitutionally exempt from local jurisdiction regulations whenever using property under its control in furtherance of its educational purposes. However, UCSF seeks to cooperate with the City and County of San Francisco to reduce any physical consequences of potential land use conflicts to the extent feasible. This section summarizes regulations contained in the City and County of San Francisco Noise Ordinance relevant to noise impacts.

[6] Smith, Fause , McDonald, Inc., UCSF Campus Noise Abatement Study, Phase II, Assessment of Existing Noise Levels, Modeling, and Mitigation Measures, Southeast Campus Edge, February 24, 1998.

[7] Since the 1998 Smith, Fause, McDonald report, the noise limits of the San Francisco Noise Ordinance have changed (see Section 4.10.4). Nonetheless, for purposes of this discussion, 50/55 dBA remains the ambient noise goal for mechanical noise attenuation at the Parnassus Heights campus site.

[8] Charles Salter Associates, Inc., UCSF Parnassus Equipment Noise Study, memorandum to Diane Wong, July 21, 2010.

## 4.10.4 CITY AND COUNTY OF SAN FRANCISCO NOISE ORDINANCE

Sections 2907 and 2908 of Article 29 of the San Francisco Police Code regulate noise generated by construction equipment and construction work. Section 2907(b) states "it shall be unlawful for any person, including the City and County of San Francisco, to operate any powered construction equipment, regardless of age or date of acquisition, if the operation of such equipment emits noise at a level in excess of 80 dB(A) when measured at a distance of 100 feet from such equipment, or an equivalent sound level at some other convenient distance." The Ordinance also requires that such equipment be equipped with intake/exhaust mufflers and/or acoustically attenuating shields/shrouds recommended by the manufacturers and approved by the Director of Public Works to best accomplish maximum noise attenuation. Exemptions to the Ordinance include impact tools and equipment, pavement breakers, and jackhammers.

In addition to the 80 dB(A) noise limit, Section 2908 states that "it shall be unlawful for any person, between the hours of 8:00 PM of any day and 7:00 AM of the following day to erect, construct, demolish, excavate for, alter, or repair any building or structure if the noise level created thereby is in excess of the ambient noise level by 5 dB(A) at the nearest property plane, unless a special permit therefore has been applied for and granted by the Director of Public Works."

Section 2909 of Article 29 of the San Francisco Police Code states that "no person shall produce or allow to be produced by any machine or device, music or entertainment or any combination of same, on a commercial or industrial property over which the person had ownership or control, a noise level more than 8 dB(A) above the local ambient at any point outside of the property plane."

## 4.10.5 SIGNIFICANCE CRITERIA

### Significance Criteria

According to the Appendix G of the State CEQA Guidelines, a project would have a significant effect on the environment if it would:

- Expose people to or generate noise levels in excess of standards established in any applicable plan or noise ordinance, or applicable standards of other agencies;
- Expose people to or generate excessive ground-borne vibration or ground-borne noise levels;
- Result in a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project;
- Result in a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project;

- Result in exposure of people residing or working in the project area to excessive noise levels if the project is located within an area covered by an airport land use plan, or where such a plan has not been adopted, within 2 miles of a public airport or public use airport;

- Result in exposure of people residing or working in the project area to excessive noise levels if the project is located in the vicinity of a private airstrip; or

- Exceed an applicable LRDP EIR standard of significance by contributing to an increase in average daily noise levels ($L_{dn}$) of 3 dB(A) or more at property lines, if ambient noise levels in areas adjacent to proposed development already exceed local noise levels set forth in local general plans or ordinances for such areas based on their use.

## Issues Not Discussed Further

The Initial Study for the proposed project noted that the project would not generate excessive groundborne noise levels or vibration. The site is not included in an airport land use plan, nor is it in the vicinity of a private airstrip. Therefore, implementation of the proposed project would not be affected by operation of a public airport or by a private airstrip. The project would not contribute to an increase in average daily increase in noise levels of 3 decibels or more at the property line. These issues are not discussed further in this EIR.

While proposed management activities are not "construction" activities and the equipment used to carry out these activities is not construction equipment, the noise impacts of implementing the proposed project are analogous to construction noise impacts given that the heavy equipment used in vegetation management and their use on a short-term basis are equivalent to construction equipment in the context of this analysis. Thus, the term "construction noise" is used to refer to this impact.

As discussed in the Initial Study, to minimize construction noise impacts on nearby residences, the following LRDP EIR mitigation measure which exceeds requirements of the San Francisco Noise Ordinance for construction hours, is included in the proposed project. Implementation of this mitigation measure ensures that construction noise impact associated with the use of heavy equipment would be less than significant. Thus, this topic need not be analyzed further in the EIR.

> **Mitigation Measure #2: Construction Noise:** Use of heavy equipment for management activities would, on a temporary basis, elevate noise levels in and around the project site, and particularly at nearby sensitive receptors. UCSF shall require contractors to minimize unavoidable construction noise impacts by use of proper equipment and work scheduling. Construction hours shall be limited to the following schedule:
>
> - Monday through Friday, 7 a.m. to 5 p.m. for not noisy work (80 decibels or less at 100 feet)
> - Monday through Friday, 8 a.m. to 5 p.m. for noisy work (more than 80 decibels at 100 feet)

- Extended hours only with advanced 24-hour notice from the UCSF project manager (Monday through Friday, 5 p.m. to 8 p.m.; Saturday 7 a.m. to 8 p.m.; and Sunday 8 a.m. to 4:30 p.m.)
- No noisy work on Saturdays and Sundays.

The Initial Study noted that mechanical equipment noise is generated by on-campus buildings, and is particularly noticeable near the power plant and Moffitt/Long hospitals on the east side of the campus, near the Edgewood area of the Reserve. The Edgewood area of the Reserve provides a buffer in distance, visibility, and possibly noise between campus buildings and the residences to the east which have rear yards that abut the Reserve. The analysis below discusses whether significant impacts may result from the modest tree thinning and vegetation removal proposed for the Edgewood area of the Reserve. Other residences along the perimeter of the Reserve are too distant from the power plant and Moffitt/Long hospitals for proposed management actions to affect their noise exposure in a meaningful way.

### Significance Thresholds

For the purposes of this EIR, noise impacts resulting from the proposed project would be considered significant if the project would expose persons to a substantial increase in noise levels.

## 4.10.6 IMPACTS AND MITIGATION MEASURES

**Impact NOISE-1: Proposed forest thinning and understory removal activities in the Edgewood area could expose nearby residents to a substantial increase in noise levels. (Significant)**

As discussed above, ambient noise measurements were taken in 2010 to determine the effectiveness of noise attenuation measures taken to date to reduce rooftop mechanical noise generated on the campus. Noise measurements were taken within the Reserve at the rear of the Edgewood Avenue residences, and within the nearby Surge parking lot, where the noise from rooftop mechanical equipment and the power plant was most dominant. Two of the noise measurement locations within the Surge parking lot were selected to determine the extent to which the trees and vegetation provide a noise buffer to the Edgewood Avenue residences. One measurement location had an unobstructed line of sight (and sound) between the residences and the campus, and the other location was obstructed by trees and vegetation to a depth of about 75 feet. Short-term measurements revealed that the trees did provide a slight noise buffer. The noise level at the unobstructed location was 59 dBA $L_{eq}$, and the obstructed location had a noise level of 57 dBA $L_{eq}$. Thus, the trees and vegetation provided a noise buffer at the measurement location of about 2 dBA, which is not quite perceptible by the human ear. The degree of noise buffering that trees and vegetation provide in the Edgewood area will vary depending on the specific location in question, the density of trees/vegetation, topography, and weather, including factors such as temperature, humidity and wind.

The 2010 noise study found that modifications to existing equipment and new equipment installed since the 1998 noise study have further reduced the overall noise levels measured, ranging from about 48 to 59 dBA over a continuous period of one week. While in 2010 the campus still did not meet the 50/55 dBA goal in all instances where noise was measured, overall noise levels were determined to be less than in 1998, and are expected to continue to decline as more mechanical equipment is upgraded and replaced.

Tree thinning and understory removal could lessen the effectiveness of the noise buffer for residences near the eastern stretch of forested land between the northern end of Medical Center Way and the Surge building, where the rear yards of Edgewood Avenue residences abut the Reserve. If tree thinning and understory removal occurs within this area, the noise buffer may be made less effective, which may expose Edgewood Avenue residents to increased noise levels generated by on-campus mechanical equipment.

While the increased exposure may be about 2 dBA, which is not quite perceptible, the noise levels could vary, as discussed above. Structures, even residential buildings, would provide quite a bit of noise attenuation and further limit the noise exposure in the interior of residences, even with windows open.

Because the degree of potential increased noise exposure is not certain, and because the campus has not yet reached its ambient noise goal of 50/55 dBA, noise impacts of the proposed project are considered significant. This conclusion is conservative because as indicated above, noise exposure within the interior of residences would be attenuated by the residential structure itself, and the campus is continuing to work toward reduced noise levels generated by on-campus rooftop mechanical equipment. The conclusion is also conservative because the likely increase in noise exposure would be about 2dBA $L_{eq}$,, less than the standard of significance under the LRDP EIR which is a contribution to an increase in average daily noise levels ($L_{dn}$) of 3 dBA or more.

**Mitigation Measure NOISE-1**: To reduce the degree of increased noise levels to which residents may be exposed, the following measures shall be taken:

- The University shall limit to the extent feasible trees and/or vegetation to be removed within the eastern stretch of forested land between the northern end of Medical Center Way and the Surge building, adjacent to the rear yards of Edgewood Avenue residences, while achieving its goals of improving forest health and reducing the risk of wildfire.
- The University shall consider any requests by residents adjacent to these areas to plant trees and/or vegetation that may be less flammable than eucalyptus, to provide some degree of noise buffering.
- The University shall continue efforts to upgrade and replace rooftop mechanical equipment to reduce over time ambient noise levels to achieve the 50/55 dBA goal.

**Significance After Mitigation:** Significant and Unavoidable

While the mitigation measures identified above will reduce the impact of increased noise level exposure, the amount of increased noise level exposure is not certain. As such, the mitigation

measures cannot guarantee that noise levels would be reduced to less than significant levels. Therefore, this impact is considered significant and unavoidable.

**Impact NOISE-2: Proposed forest thinning and understory removal activities could have a substantial adverse cumulative effect with regard to exposing nearby residents to increased noise levels. (Less than Significant)**

There are no other proposed activities within the vicinity that would expose Edgewood Avenue residents to permanent increases in noise levels. The City and County of San Francisco proposes a modest amount of tree removals and vegetation management within the Interior Greenbelt area situated on the south side of Edgewood Avenue residences. However, there are no other substantial noise sources in the vicinity for which the Interior Greenbelt provides a noise buffer. Therefore, the vegetation management activities proposed for the Interior Greenbelt would not expose Edgewood Avenue residents to permanent elevated noise levels, and no cumulative impact with regard to increased noise exposure would result. Thus, the proposed project would not contribute to a cumulative adverse impact related to noise exposure to nearby residents.

**Mitigation:** None required.

## 4.10.7 REFERENCES

Charles Salter Associates, Inc., UCSF Parnassus Equipment Noise Study, memorandum to Diane Wong, July 21, 2010.

# 4.11 WIND

## 4.11.1 INTRODUCTION

This section describes the existing site conditions, methodology and results used to quantify the current ("baseline") wind environment, and CEQA regulatory setting for the 61 acre Mount Sutro Open Space Reserve ("Reserve"). This section also evaluates wind-related impacts associated with the proposed management activities across the Reserve. It includes an analysis of impacts associated with windthrow in the Reserve, and wind impacts to surrounding neighborhoods.

Comments related to wind received during the Initial Study/EIR scoping process included concerns about the following:

- Reducing the effectiveness of the windbreak provided by the dense forest, thereby increasing wind speeds within the Reserve and adjacent neighborhoods
- Effects on tree health as result of exposure to winds
- A potential increase in the spread of wildfire by reducing the windbreak formed by the dense forest and by altering wind patterns (this topic is discussed in Section 4.7 Hazards – Fire Hazards)

## 4.11.2 ENVIRONMENTAL SETTING

### 4.11.2.1 REGIONAL CLIMATE

Climate is the multi-year long-term average of daily weather cycles that occur over a large geographical area. Regional climate is the average of long term weather cycles over a smaller and more specific area. Often times, these smaller areas are defined by air basins, in which air currents may normally flow freely until confronted by elevated terrain or air mass differences from other basins. Regional climate can be affected by large scale changes in the atmosphere, local changes in vegetation cover or short-term weather changes.

The climate of the San Francisco Bay region, along with much of coastal California, is controlled by a semi-permanent high-pressure system that is centered over the northeastern Pacific Ocean. Beginning in the autumn and continuing through the winter, the high-pressure system weakens and moves south, allowing storm systems originating from the Gulf of Alaska and the Pacific Ocean into the area. Temperature, winds, and rainfall are more variable during these months. Occasionally the broad scale circulation pattern permits a series of storm centers to move into California from the southwest. This type of storm pattern is responsible for occasional heavy rains that may cause serious flooding (WRCC 2012a). Average high and low temperatures and precipitation data are presented in Table 4.11-1 for the San Francisco Mission Dolores weather station. The Mission Dolores station is the nearest station to the project site that currently measures temperature and precipitation, and is readily available by the Western Regional Climate Center (WRCC).

Winds in San Francisco are generally from the west, off the Pacific Ocean. The average wind speed is greatest in the spring and summer months, and lower in the fall and winter, except during storm events. Daily variation in wind speed demonstrates the strongest wind speeds in the late afternoon and lightest winds in the morning. Windthrow (the uprooting and overthrowing of trees by wind) is often more important in mid and upper slopes than in lower slopes (Navratil 1995), and wind blowing perpendicular to edges are most damaging (Ruel 1989).

**Table 4.11-1**
**San Francisco Mission Dolores Monthly Climate Summary**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Max. Temperature (F) | 56.5 | 59.8 | 61.5 | 62.8 | 63.9 | 66.1 | 65.8 | 66.7 | 69.8 | 69.1 | 63.7 | 57.3 | 63.6 |
| Average Min. Temperature (F) | 45.7 | 47.9 | 48.8 | 49.7 | 51.1 | 52.9 | 53.7 | 54.5 | 55.5 | 54.4 | 51 | 46.8 | 51 |
| Average Total Precipitation (in.) | 4.35 | 3.81 | 2.9 | 1.42 | 0.57 | 0.16 | 0.02 | 0.05 | 0.22 | 1.05 | 2.57 | 4.04 | 21.15 |

Period of Record: 1914-2012

Source: WRCC, 2012b.

Table 4.11-2 presents wind data from the San Francisco airport. The prevailing wind direction at the San Francisco Airport is westerly. The consistent westerly winds are caused by the combination of the high pressure offshore and a thermal low pressure resulting from higher temperatures inland. On average, the wind speed is around 4.7 meters per second (m/s) or 10.5 miles per hour (mph). Wind gusts are strongest in the winter months from November to March; the highest recorded at the airport was 33 m/s (73.8 mph) in December 1995.

Strong winter storms bring powerful wind events to the San Francisco area, where wind gusts can reach 45 m/s (100 mph) along the northern coast of California; wind gusts at these speeds have been known to cause the windthrow of trees (McBride and Leffingwell, 2006). Sometimes these wind events are combined with heavy precipitation, which can result in falling tree branches and windthrown, uprooted trees.

**Table 4.11-2**
**San Francisco Airport Winds Information**

| | (a) | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WIND** | | | | | | | | | | | | | | |
| **Mean Speed (m/s)** | 68 | 3.2 | 3.8 | 4.7 | 5.5 | 6.0 | 6.3 | 6.1 | 5.7 | 5.0 | 4.2 | 3.4 | 3.2 | 4.7 |
| Mean Speed (mph) | 68 | 7.2 | 8.5 | 10.5 | 12.3 | 13.4 | 14.1 | 13.6 | 12.7 | 11.2 | 9.4 | 7.6 | 7.2 | 10.5 |
| Prevailing Direction through 1964 | | WNW | WNW | WNW | WNW | W | W | NW | NW | NW | WNW | WNW | WNW | WNW |
| **Peak Gust** | | | | | | | | | | | | | | |
| Direction | 12 | S | S | S | NW | NW | W | W | W | NW | S | S | SW | SW |
| Speed (m/s) | 12 | 27.3 | 30.8 | 28.6 | 24.1 | 25.9 | 22.8 | 23.2 | 20.1 | 19.7 | 25.9 | 26.8 | 33.1 | 33.1 |
| Speed (mph) | 12 | 61.1 | 68.9 | 64.0 | 53.9 | 57.9 | 51.0 | 51.9 | 45.0 | 44.1 | 57.9 | 60.0 | 74.0 | 74.0 |
| -Date | | 1995 | 1986 | 1995 | 1984 | 1984 | 1984 | 1987 | 1992 | 1994 | 1989 | 1984 | 1995 | Dec-95 |

(a) - Length of Record in Years, although individual months may be missing.

0.* or * - The value is between 0.0 and 0.05.

Normals - Based on the 1961 - 1990 record period.

Extremes - Dates are the most recent occurrence.

Wind Dir.- Numerals show tens of degrees clockwise from true north.

Resultant Directions are given to whole degrees.

DATA FROM WRCC:
http://www.wrcc.dri.edu/cgibin/clilcd.pl?ca2324

Wind data is also readily available from National Ocean and Atmospheric Administration (NOAA) for buoys near the San Francisco coast line (NOAA 2012). A buoy is located approximately 0.75 miles east of the Golden Gate Bridge in the San Francisco Bay. The buoy is near the southern shore, just north of the Gulf of the Farallons National Marine Sanctuary (37.807 N, 122.465 W).

NOAA buoy data has been quality assured, and has measurement for wind direction, average wind speed, and wind gusts collected approximately every 6 minutes, or 10 observations per hour. Data from 2007, 2008, 2009, and 2011 were collected from the National Buoy Data Center. Buoy data from 2010 was not used for this analysis, as the year had insufficient data capture. A windrose for the data is shown in Figure 4.11-1. The average wind speed is approximately 3.3 m/s (7.4 mph) at the buoy, with winds mainly from the west and southwest.

The slight differences in wind speed and direction between the NOAA data and the SFO data may be attributed to a number of different site conditions including topography, obstructions to wind fetches, site characteristics and instrument heights. The NOAA data is from a buoy right on top of the water in the bay, while SFO's data is from a 10 meter tower located in the middle of an airstrip.

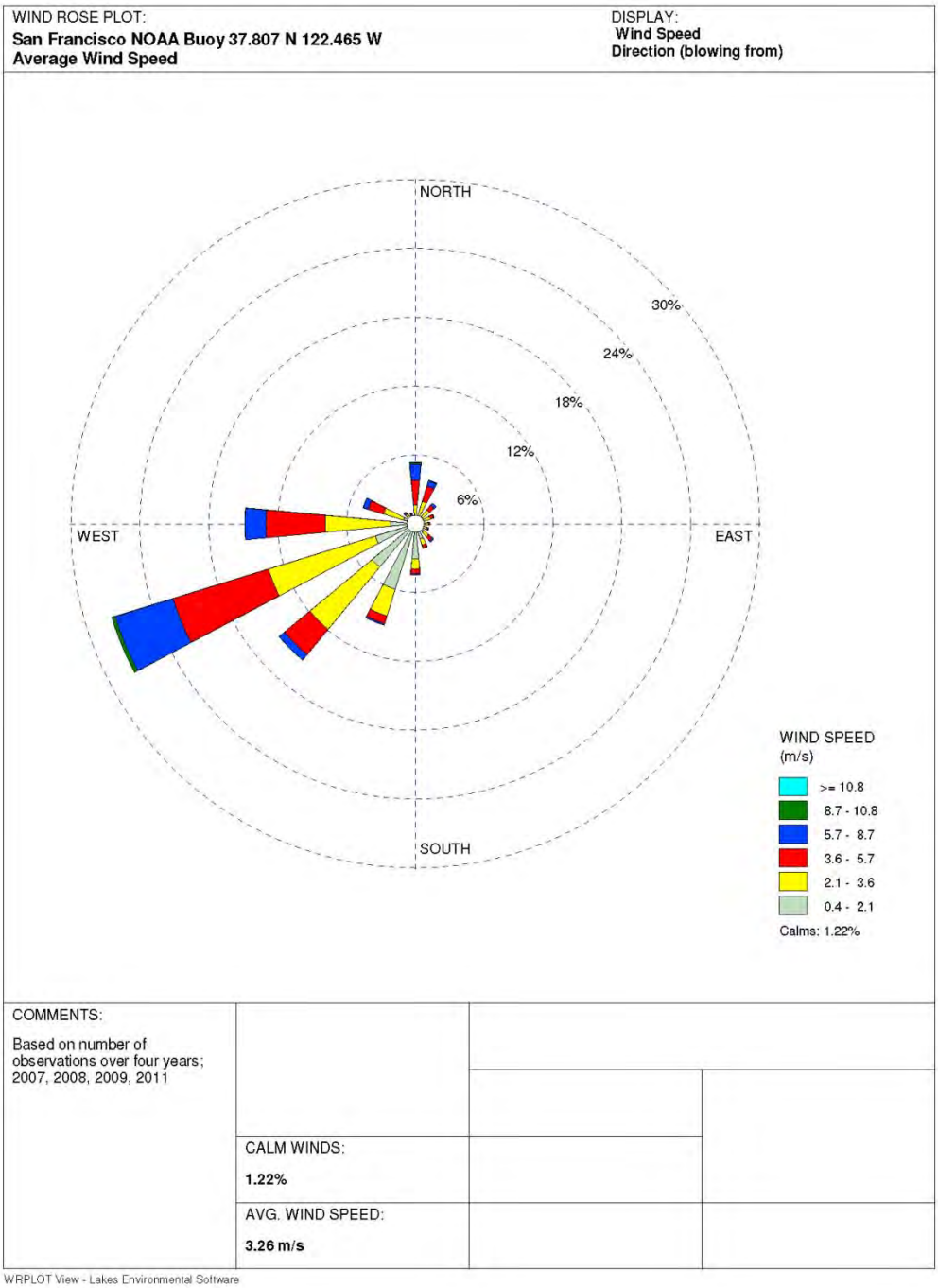



**Figure 4.11-1**
San Francisco NOAA Buoy Wind Rose
2007-2009,2011

Gusty wind events exceeding 22.4 m/s (50 mph) from the west and north occur throughout the year at the buoy station. These gusts are usually short, instantaneous wind speed bursts, but may occur several times in one day. Table 4.11-3 shows the number of days in a year where winds equaled or exceeded 22.4 m/s (50 mph) during 2007-2009 and 2011.

**Table 4.11-3**
**Number of Days in Year Wind Gusts Equaled or Exceeded 22.4 m/s (50 mph)**
**NOAA Buoy 9414290 - San Francisco, CA**

| 2007 | 2008 | 2009 | 2011 |
|---|---|---|---|
| 50 | 1 | 20 | 48 |

*Source: National Buoy Data Center (NOAA, 2012)*

## 4.11.2.2 WINDTHROW

### Literature and Definitions

One potential result of high winds is windthrow, defined as the uprooting and overthrowing of trees by wind. Wind disturbances, from small-scale to stand-replacing, can exert strong impacts on forest structure in forested ecosystems (White and Pickett 1985, Foster et al 1998; Kramer et al 2001). Many factors affect windthrow. Research has shown that both biotic (of or related to living things) and abiotic (physical rather than biological) factors determine how windstorms impact forested ecosystems (Everham and Brokaw 1996); researchers have long debated the relative influence of these. Abiotic factors affecting the amount of wind damage include wind speed, topography and soils. Examples of biotic factors that influence wind events in forests include tree composition, interactions with other mortality factors like forest pathogens and pests, and tree density. These factors interact in complex patterns and their relative importance can change with each new wind event.

Windthrow events typically occur during storm or high wind events. While high and low wind speeds are not officially defined, for the purposes of this report, low wind events are defined as average wind speeds of less than 8 mph, where wind can be felt on the face, but is not sufficient to lift material. At low-moderate wind speeds (8-13 mph) wind will disturb hair, can cause clothing to flap, or can extend a light flag mounted on a pole. Moderately high winds (13-26 mph) can raise loose paper and dry soil from the ground and can be felt on the body. High wind events (greater than approximately 26 mph) are defined here as those that impede walking and lift items larger than loose paper from the ground (based on definitions from Arenas 1981).

High wind velocities are common along the north coast of California; high velocity wind gusts sometimes reach 45 m/s (100 mph) in the San Francisco area, and are highest in the winter months of November to March (see Section 4.11.2.1, Regional Climate, San Francisco Airport). For instance, a severe windstorm occurred in San Francisco on December 13, 1995, with winds of 33 m/s (93 mph) recorded on the Golden Gate Bridge. This storm resulted in the windthrow of an

estimated 6,000 trees in the Presidio causing damage to many structures, road closures, and one death (McBride and Leffingwell 2006). On the basis of field observations and a literature review, McBride and Leffingwell evaluated the role of the three most important landscape characteristics associated with windthrow of the Presidio trees: soil type, topography, and tree species. These variables are discussed below followed by an analysis of tree density and other biotic factors as they pertain to windthrow impacts in the Reserve.

## Windthrow Risk Abiotic Factors

Windthrow is often associated with shallow soils that are subject to saturation; shear strength of soils decreases with increasing moisture content and is also very low in soil textures dominated by sand. A total of one soil map unit, the Candlestick-Kron-Buriburi Complex 30-75% slopes, is present within the Reserve (NRCS, 2012). This soil map unit is primarily composed of three soil series, 40% of which is the Candlestick series (or similar soils), 25% Kron series (or similar soils), and 20% Buriburi series soils (or similar soils). These soil series primarily have a loam texture (texture varies from fine sandy loam to sandy clay loam). Both the Candlestick and the Buriburi series have moderate depth to bedrock (20-40 inches to bedrock and 30 inches to bedrock, respectively) whereas the shallow Kron series typically has a depth of 10-20 inches above bedrock. All three series are well drained. Overall, the soils are not excessively shallow nor are they excessively sandy. However, in certain areas, such as within the more shallow areas covered by Kron series soils, the soil shear strength could decrease sufficiently after a significant precipitation event. Such an event would lead to increased risk of windthrow. For more information on soils, see Chapter 4.5 Geology and Soils.

A geotechnical and geological evaluation report prepared for the site identifies site geology and analyzes associated slope stability (R&C 2011). Generally areas identified as having unstable colluvium were determined to be less stable and more susceptible to landslides compared to areas underlain with Franciscan Chert (R&C 2011). Areas with unstable geology are prone to landslide events and could be higher risk areas for windthrow.

The topographic setting of a site can also greatly influence exposure to wind. Sites located on high ridges, in topographic saddles, and at the heads of canyons are sites that experience high wind velocities (Harris 1989). Aspect is important; areas more prone to windthrow would be expected to be slopes directly facing prevailing winds (Harris 1989). Windthrow is often more important in mid and upper slopes than in lower slopes (Navratil 1995), and wind blowing perpendicular to edges are most damaging (Ruel 1989). Topography varies throughout the Reserve and may play an important role in wind speeds within the Reserve.

## Windthrow Risk Biotic Factors

Tree density is one of the biotic factors that impacts windthrow risk. Windthrow risk is exacerbated by the opening of forests stands to accommodate roads and provide building sites during urbanization (McBride and Leffingwell 2006). Though gap sizes left by thinning will be on average smaller than those left by building sites or road building activities, thinning of trees

can be expected to have a similar impact in allowing increased wind penetration into the Reserve. Trees once protected by neighboring trees would now be exposed to greater wind speeds.

One study in the Pacific Northwest found that, in a comparison of thinned versus non-thinned plots, the overall level of wind damage across all thinned plots after two growing seasons was not statistically greater than in unthinned control plots. However, where gaps (e.g. thinning areas) were located in topographically vulnerable positions, greater wind damage did occur (Roberts et al 2007). This suggests that tree thinning will not have a consistent impact on windthrow risk, but will depend on topographical vulnerability.

In addition to this, there is a timing factor. While thinning can initially increase the risk of wind damage to trees, trees can become adapted to their new environment. Trees eventually adjust the allocation of stem and crown growth, resulting in a more stable configuration (Wonn and O'Hara 2001). Thinning promotes diameter growth more than height growth, so thinned stands develop lower height to diameter ratios over time. In this way, the risk of wind damage can be greatly reduced following thinning, and studies have shown that reducing stand density can lead to a greater long-term wind-firmness (Cremer et al 1982, Wonn and O'Hara 2001).

Another biotic factor predicting risk of windthrow is species composition. Tree species vary in their susceptibility to windthrow due to factors like shear strength of wood, root structure, and canopy structure (McBride and Leffingwell 2006). McBride and Leffingwell (2006) found that, based on these factors, the relative risk of windthrow for the dominant species in the Presidio was Monterey cypress *(Cupressus macrocarpa*), Monterey pine (*Pinus radiata*), then, most robust, blue-gum eucalyptus (*Eucalyptus globulus*). The Reserve is dominated (82%) by blue-gum eucalyptus, with small amounts of other tree species including Monterey pine and Monterey cypress, as well as blackwood acacia (*Acacia melanoxylon*), and coast redwood (*Sequoia sempervirens*) (Hortscience 1999, UCSF 2010). Though blue-gum eucalyptus fares well compared to other species found in the Reserve, their shallow root systems are of concern. Trees with shallower root systems are more susceptible than trees with deeper root systems (Burns and Honkala 1990). Indeed, downed trees have already been seen throughout the Reserve. HortScience, in their 1999 report, noted that tree failures, particularly windthrow of entire trees, were common occurrences. The proposed management actions may lead to a conversion in species composition (e.g. through planting) that adds species that are more robust (e.g. coast live oak (*Quercus agrifolia*), bay laurel (*Umbellularia californica*) or less robust (e.g. Monterey cypress, Monterey pine) to windthrow. Any changes in species composition could impact the Reserve's resiliency to windthrow.

Finally, removal of dead, dying, unhealthy, and hazardous trees (see Chapter 3, Project Description) would be expected to reduce windthrow risk in the Reserve in at least two ways. First, dead and diseased trees are structurally compromised and would be most likely to fail during high wind events, often falling onto other trees (even healthy trees) and increasing their risk of failure. This increases the size of gaps left by windthrow, which increases the risk of future greater wind damage (Roberts et al 2007). Second, as stated above, the remaining healthy trees are predicted to grow larger through release from competition, and this increase in growth would

occur through diameter growth more than height growth. Remaining healthy trees would be more robust to windthrow.

### Windbreaks

Trees may serve as windbreaks that can reduce wind speeds in adjacent areas. A windbreak is defined as is a tall, dense, continuous wall of vegetation. The height determines how far wind protection extends, and the density determines the degree of protection. The general rule is that a windbreak will reduce wind to a distance 10 times its height and reduce wind speed 70 to 80 percent immediately inside the barrier (Kansas State University 2004; Wisconsin Department of Natural Resources 2003). The degree of protection from a windbreak gradually decreases with distance (Kansas State University 2004). Four basic factors are considered when designing a windbreak: its orientation in relation to the prevailing winds, its width, plant and density arrangement, and the species of plants selected (Ohio State University 2012).

Windbreak density affects the pattern of air movement around the windbreak. Wind velocity is reduced as the density of the windbreak is increased, and, as a result, the area protected tends to be increased. Density depends upon the type of trees and shrubs and the number of rows planted. Density within a windbreak can be increased by planting multiple rows of evergreen trees. Finally, wind eddies (or, small-scale air turbulence) will form around the edges of a windbreak. Therefore, windbreaks should extend at least 100 feet beyond the area to be protected. Any gaps will funnel the wind, eliminating much of the windbreak's effectiveness (Kansas State University 2004).

A standard farmstead windbreak has at least three rows: the outside or windward row; one or more interior rows; and the inside or leeward row. Four to six rows provide greater protection, but even one or two rows are beneficial. The standard Wisconsin Department of Natural Resources windbreak packet contains 200 spruce and 100 white or red pine- enough stock to plant a 3-row windbreak that is 800 feet long (Wisconsin Department of Natural Resources 2003). Three hundred (300) feet is the minimum windbreak width recommended (Hess and Bay 1994).

## 4.11.2.3 WIND CONDITIONS AT MOUNT SUTRO

Mount Sutro is roughly 400 to 900 feet above sea level with exposed high terrain above the city level, featuring distinct topographic features and forested areas. It can be expected that higher wind gusts occur throughout the year at exposed locations on Mount Sutro compared with winds measured at the buoy station or San Francisco Airport. In addition, the highly variable topography and vegetation cover within the Reserve affects both the wind speed and direction variability. Densely forested areas of Mount Sutro would be expected to experience reduced winds compared to sparser areas, all other variables held equal. Topographically sheltered locations would also be expected to experience reduced winds.

Daily (diurnal) wind patterns occur around elevated terrain like the higher areas of the Reserve. In the morning the sun warms the air at the land surface and causes it to expand and rise

vertically. The atmosphere near the elevated terrain is slightly less dense because it is higher in elevation. As this air is slightly less dense and frequently drier than the air at sea level it heats more quickly, buoyantly rising. The atmosphere constantly tries to balance between areas of low pressure and areas of high pressure, and the winds flow from higher pressure areas to lower pressure areas. In the daytime this causes wind flow from sea level toward the mountains, or upslope winds. In the evening the wind pattern is reversed. The air in elevated terrain cools more quickly than air near sea level, and this cooler air will start flowing downhill. This pattern is called downslope winds.

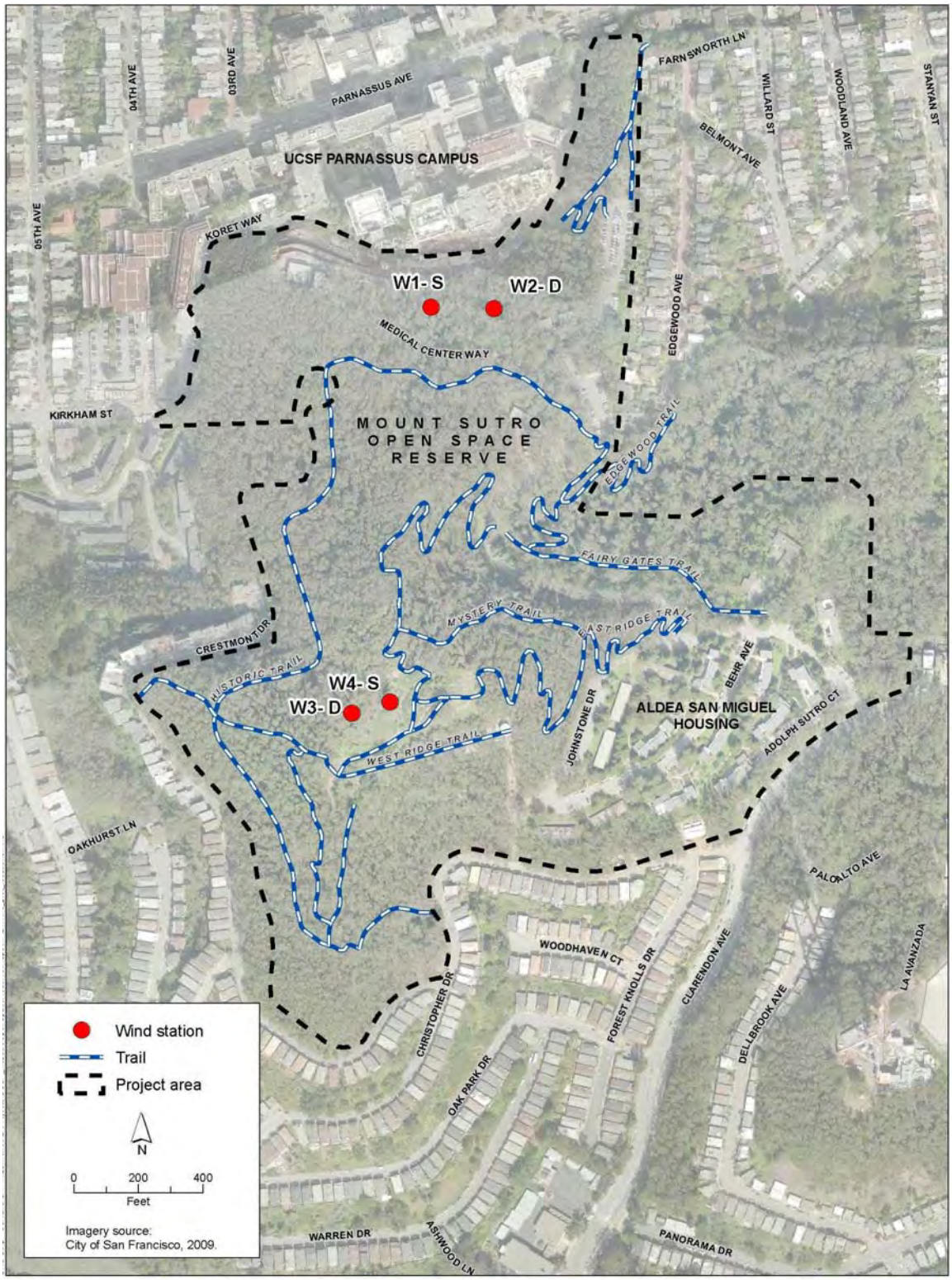
Onshore and offshore wind patterns also impact the wind patterns at the Reserve. These are created by temperature differences at the land surface, similar to the upslope and downslope wind pattern mechanisms. In the morning the land heats more quickly than the water causing the air over the land to heat, expand and rise. This creates an area of lower pressure over land and causes air to move from the water to the land at the surface; this phenomenon is called an onshore wind or sea breeze. In the evening, the land cools faster than the water causing the air over the land to cool, get denser and flow toward the relatively lower pressure over water, thus creating an offshore wind or land breeze. The sea breeze-land breeze flow pattern is often the primary wind pattern mechanism in coastal California; it may be interrupted only by high and low pressure systems, frontal passages, and storms.

In the winter, when the Pacific high pressure system weakens and moves towards the south, low pressure systems frequently pass through the project area. The counterclockwise wind flow around low pressure systems creates a sometimes easterly flow during the winter months.

## Mount Sutro Open Space Reserve Wind Station Data

To investigate the wind environment in the Reserve, Vantage Pro2 Weather Stations (manufactured by Davis Instruments) were installed in the Reserve. The stations were established in two paired plots for a total of four wind stations. The goal in placement of the paired plots was to locate one station in an area of sparse tree cover and the other nearby (within 150 feet) in an area of dense tree cover, controlling for the other major variables that impact wind speed and direction (e.g. topo-position, aspect, elevation) wherever possible. Further, the sparsely-forested plots were chosen to match the 30 foot average spacing between trees proposed in UCSF's vegetation management plan (UCSF 2010).

Figure 4.11-2 identifies the location of the wind stations in the Reserve. Wind stations 1 and 2 (referred to as dataset 1) were located just north of Medical Center Way and west of the Surge Building close to the bottom of Mount Sutro. Wind station 1 was sited in an area of sparse (S) forest cover approximately 100 feet due west of wind station 2 which was located in an area of dense (D) forest cover. The two stations were located at equal elevation (610 feet), aspect (N), and topoposition.




Source: URS

**Figure 4.11-2**
Wind Station Locations

Wind stations 3 and 4 or dataset 2, were located near the Rotary Garden close to the top of the Mount Sutro Open Space Reserve. Wind station 3 was located in an area of dense (D) forest and wind station 4 was located approximately 50 feet east in a sparse (S) forest. The two stations were at an approximately equal elevation (855 feet) and aspect (NNW)); station 4 was in a slightly different topo-position at the top of the hill where a clearing (the Rotary Native Plant Garden) begins, whereas Station 3 was located just below the crest of the hill. Station 4 was abutted by bushes of an average height of 8 feet on its west and north sides, and by a meadow to its east and south.

All four wind stations were installed for a total of 39 days between May 31 and July 9, 2012. However, (station 1 malfunctioned for the first 8 days of collection and was replaced). For all stations, measurements were taken every 10 minutes for 6 observations per hour per machine. Wind direction and wind speed were measured by an anemometer located at approximately 6.5 feet above the ground. Wind speed data was collected in miles per hour (mph); because the windrose software (WRPLOT View- Lake Environmental Software) converts to meters per second (m/s), all wind speeds in this section have also been written in m/s. One m/s is equal to 2.237 mph. Wind direction data was taken in a sector format (e.g. N, NNE, NE) for every 22.5 degrees or 16 separate sectors. The data was converted to degrees for the windroses software and petals were created for the 16 different sectors. Table 4.11-4 presents a data summary for all four wind stations described above. Windroses and wind speed and direction frequency tables for each station can be found in Appendix J, Wind Data.

**Table 4.11-4 Wind Data Summary by Station**

| | Number of Observations | Data Capture | Average Wind Direction | Average Wind Speed, m/s (mph) | Percent Calm | Max Gust Speed, m/s (mph) |
|---|---|---|---|---|---|---|
| Station 1 (Sparse) | 4618 | 82% | WNW | 2.3 (5.21) | 23% | 16.1 (36.0) |
| Station 2 (Dense) | 5654 | 100% | NNW | 0.01* (0.02) | 97% | 4.0* (8.9) |
| Station 4 (Sparse) | 5654 | 100% | S | 0.14 (0.31) | 85% | 5.8 (13.0) |
| Station 3 (Dense) | 5632 | 100% | SE | 1.87 (4.18) | 27% | 10.3 (23.0) |

*The same numbers were also computed for the common 31-day measurement period shared between station 1 and station 2.

Results indicate that wind data from the different stations on Mount Sutro were highly variable, though higher wind speed gusts consistently occurred in afternoon to late evening hours, and, in general, calmer winds occurred during night hours when the atmosphere was less turbulent. Variable wind direction measurements seemed to depend on obstructions found near each particular station, such as vegetation or topographic features.

Station 2 (located in a very densely forested area) measured winds that were calm (low wind speeds) approximately 99% of the time during the 39-day measurement period. During the small number of times when non-zero wind speeds were measured at station 2, wind speeds were very light (0.4-0.9 m/s, 1-2 mph) and limited to the NNW direction, presumably due to the obstructing forest surrounding the station. The average wind speed at station 2 was only 0.01 m/s (0.02 mph)

over the whole data period due to the large number of calms, or zeros, in the wind speed data. The maximum wind gust reading at station 2 was 4 m/s (9 mph). Just to the west of station 2, station 1 (located in sparse forest) experienced an average wind speed of 2.3 m/s (5.2 mph), with much higher gusts than measured at station 2. Here the maximum gust speed was 16.1 m/s (36 mph). According to these averages, wind station 2 experienced 23 times lighter average wind speeds, and 4 times lighter wind gusts, than the neighboring station 1. Wind directions for station 1 were mainly from the western direction.

Table 4.11-5, Station Winds Analysis by Time Correlation, presents data from each station by controlling the date and time variable to compare wind speed and wind direction measurements occurring at the same time at each station. Four local timestamps were chosen: morning (7 AM), afternoon (1 PM), evening (7 PM), and night (1 AM); while four random dates were chosen for this correlation study: June 10, 17, 25; and July 5.

For dataset 1, Table 4.11-5 confirms that station 2 experienced calm winds during all times of the day with occasional short-term light gusts from the north or northwest during the afternoon or evening hours. Station 1 measured more fluctuating wind directions in the morning and night hours, while during the afternoon and evening, wind direction was consistently from the WNW. Wind gusts at station 1 for these times were on the order of 2.2-13 m/s (5-29 mph), mostly from the WNW. Station 1 also measured average wind speeds of 0.9-6.7 m/s (2-15 mph) higher than station 2, while wind gusts at station 1 were 2.2-11.2 m/s (5-25 mph) higher than measured at station 2.

For dataset 2, stations 3 and 4 had average wind directions from the southern sectors. As shown in Table 4.11-5, station 3 experienced higher wind speeds than station 4, with an average wind speed of 1.87 m/s (4.2 mph) compared to station 4's average wind speed of 0.14 m/s (0.3 mph). The maximum wind gust at station 3 (10.3 m/s, 23 mph) was nearly double that of station 4 (5.8 m/s, 13 mph). The timestamp data reveals that station 4, located in sparse forest, measured average winds 0-4.5 m/s (0-10 mph) higher than station 3. Winds for station 3 were from the southeast during all times of day, with the exception of during night hours, when wind direction was more variable. Wind directions at station 4 were consistently from the south for most times of day, while similarly to Station 3, wind directions during night hours also varied. These findings were counter to expectation as station 3 was located under denser forest cover than station 4. However, as described above, station 4 was located near high bushes and at a different topoposition than station 3; both factors most likely obstructed wind flow measurements compared to the conditions experienced at station 3.

**Table 4.11-5 Station Winds Analysis by Time Correlation**

| Date | Time | Time of Day | Dataset 1 | | | | | | Dataset 2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Station 1/Sparse Forest | | | Station 2/Dense Forest | | | Station 4/Sparse Forest | | | Station 3/Dense Forest | | |
| | | | Wind Spd (m/s) | Wind Dir | High Spd (m/s) | Wind Spd (m/s) | Wind Dir | High Spd (m/s) | Wind Spd (m/s) | Wind Dir | High Spd (m/s) | Wind Spd (m/s) | Wind Dir | High Spd (m/s) |
| 6/10/2012 | 7:00 AM | Morning | 0.9 | SE | 2.2 | 0 | -- | 0 | 0 | NNW | 0.9 | 0 | SSE | 1.3 |
| 6/17/2012 | 7:00 AM | | 2.2 | NW | 3.6 | 0 | -- | 0 | 0 | NW | 0.9 | 0 | SE | 1.3 |
| 6/25/2012 | 7:00 AM | | 0.9 | SW | 2.7 | 0 | -- | 0 | 0 | --- | 0 | 0 | --- | 0 |
| 7/5/2012 | 7:00 AM | | 2.7 | WNW | 6.7 | 0 | -- | 0 | 0 | --- | 0 | 0 | ESE | 1.3 |
| 6/10/2012 | 1:00 PM | Afternoon | 2.7 | WNW | 6.7 | 0 | -- | 0 | 0 | NNW | 0.9 | 0.9 | SSE | 2.7 |
| 6/17/2012 | 1:00 PM | | 5.4 | WNW | 11.2 | 0 | NNW | 2.7 | 0 | WNW | 0.4 | 1.8 | SE | 3.6 |
| 6/25/2012 | 1:00 PM | | 2.7 | WNW | 5.8 | 0 | NNW | 0.9 | 0 | --- | 0 | 0.9 | SE | 2.7 |
| 7/5/2012 | 1:00 PM | | 4.9 | WNW | 10.3 | 0 | -- | 0 | 0 | NW | 0.9 | 3.6 | SE | 5.4 |
| 6/10/2012 | 7:00 PM | Evening | 3.1 | WNW | 6.7 | 0 | -- | 0 | 0 | NW | 0.4 | 1.8 | SE | 4.0 |
| 6/17/2012 | 7:00 PM | | 3.6 | W | 8.0 | 0 | -- | 0 | 0 | W | 0.4 | 1.3 | SE | 3.6 |
| 6/25/2012 | 7:00 PM | | 4.0 | WNW | 9.8 | 0 | N | 1.8 | 0 | --- | 0 | 3.6 | SE | 4.9 |
| 7/5/2012 | 7:00 PM | | 5.8 | WNW | 13.0 | 0 | NNW | 2.2 | 0.4 | WNW | 2.2 | 4.9 | SE | 6.7 |
| 6/10/2012 | 1:00 AM | Night | 1.3 | ENE | 4.0 | 0 | -- | 0 | 0.4 | N | 1.8 | 2.2 | SE | 4.0 |
| 6/17/2012 | 1:00 AM | | 6.7 | W | 11.2 | 0 | -- | 0 | 1.8 | S | 3.6 | 2.7 | NW | 4.5 |
| 6/25/2012 | 1:00 AM | | 2.2 | WNW | 4.9 | 0 | -- | 0 | 0 | --- | 0 | 3.1 | SE | 4.0 |
| 7/5/2012 | 1:00 AM | | 2.7 | WNW | 8.5 | 0 | NNW | 0.4 | 0.4 | S | 2.7 | 0 | N | 1.8 |

It is important to note that the 39-day and 31-day measurement period at these stations occurred during summer months when average wind speeds tend to be higher, but during which no major wind events occurred. Wind events during strong storm systems or frontal passages, or during strong Diablo wind events, would likely give conditions that may lead to windthrow on Mount Sutro. Both wind direction and wind speed would differ during these events as compared to this dataset.

The Mount Sutro Open Space Reserve weather station data suggests that, all else held constant, tree density can play an important role in determining wind speed and direction. Dataset 1 demonstrated a 4-fold difference in highest gust wind speed in a sparse forest compared to a neighboring dense forest. The data referenced above suggested that topography and local obstructions can be overriding factors to tree density in controlling wind measurements.

## 4.11.3 REGULATORY SETTING

There are no regulatory controls over vegetation management activities that pertain to wind conditions. CEQA does not identify any specific criterion for the evaluation of wind effects of a project. The City of San Francisco has established standards and criteria for the evaluation of wind impacts in downtown and the Van Ness Avenue Corridor; however, these standards are not considered relevant as they were developed for new buildings rather than for vegetation management projects.

## 4.11.4 METHODOLOGY AND SIGNIFICANCE STANDARDS

### Methodology

An extensive literature review of wind risks (e.g., windthrow) and factors contributing to wind-related risks was performed and summarized in Section 4.11.2.2 Windthrow. The review identified biotic and abiotic factors that determine how windstorms impact forested ecosystems and result in windthrow. In addition, wind impacts on built environments and the efficacy of trees as windbreaks was studied.

### Significance Criteria

The City of San Francisco has established criteria for the evaluation of wind impacts. To provide a comfortable wind environment for people in San Francisco, the City has established specific pedestrian-comfort, sitting-area-comfort, and wind-hazard criteria to be used in evaluating development proposed for certain areas of the City and near downtown (C-3 districts) under Section 148 of the Planning Code. However, as these criteria were developed for new buildings rather than for vegetation management projects, and are not applied to districts within the vicinity of the project, they are not applicable to establish criteria for the evaluation of wind impacts for the proposed project.

CEQA does not identify any specific criterion for the evaluation of wind effects of a project. However, based on the extensive literature review of impacts related to wind, for the purposes of this analysis a project would have a significant wind effect if it would:

- Have a substantial adverse short-term windthrow-related effect on the safety of people or structures;
- Have a substantial adverse long-term windthrow-related effect on the safety of people or structures; or
- Have a substantial adverse effect on wind environments in local neighborhoods.

## 4.11.5 IMPACTS AND MITIGATION MEASURES

**Impact WIND-1: The proposed project could have a substantial adverse short-term windthrow-related effect on the safety of people or structures. (Potentially Significant; Less than Significant with Mitigation)**

Tree removal activities could potentially alter the risk of windthrow in the Reserve and the potential for uprooted trees to affect the safety of people or structures. As detailed in Section 4.11.2.2 Windthrow, factors contributing to windthrow include wind speeds, topography, soils, forest tree composition, tree health, and tree density. Windthrow could affect the safety of people or damage structures within or adjacent to the Reserve from falling overthrown trees. Windthrow events in the Reserve could most likely occur during storm or high wind events. Tree removal activities may affect short-term windthrow risks by allowing for increased wind penetration, and by reducing the quantity of diseased or dead trees in the Reserve.

Thinning of trees would allow increased wind penetration into the Reserve, which could expose trees once protected by neighboring trees to greater wind speeds and an increased risk of windthrow. The potential for tree thinning activities to result in adverse windthrow risks would be greater in areas with other abiotic or biotic windthrow risk factors (e.g.,. steep topography).

As part of the project, UCSF would determine specifically which trees to remove with the assistance of a professional urban forester or arborist, and would make those determinations by considering the size and health of the trees, location relative to other trees and vegetation, effect on windthrow, and aesthetics, among other considerations. Removal of hazardous or diseased trees that are most likely to fail in high wind events would reduce short-term windthrow risks.

The potential adverse short-term impacts of thinning and the subsequent consequences of greater exposure of Reserve trees to higher wind speeds may be greater than the short-term benefits of removing hazardous trees in some areas of the Reserve, and could result in a net increase in windthrow risk. Therefore, this impact would be potentially significant. Implementation of Mitigation Measure WIND-1 would reduce this potential impact to a less-than-significant level.

**Mitigation Measure WIND-1:** After thinning, the project area would be regularly monitored by an urban forester or arborist to access tree health and condition. Trees prone to windthrow, e.g. dead or diseased trees or those occurring on steep slopes with limited soil for rooting, and considered a hazard to people or structures would be removed. The implementation of this measure would reduce the short-term impact of windthrow to a less than significant level.

**Significance after Mitigation:** Less than Significant

**Impact WIND-2: The proposed project could have a substantial adverse long-term windthrow-related effect on the safety of people or structures. (Less than Significant)**

Similar to Impact WIND-1, tree removal activities may affect long-term windthrow risks by allowing for increased wind penetration, by reducing the quantity of diseased or dead trees in the Reserve, and by altering the Reserve's tree composition. Thinning of trees can be expected to allow increased wind penetration into the Reserve so that trees once protected by neighboring trees would be exposed to greater wind speeds and an increased risk of windthrow. However, as described in Section 4.11.2.2 Windthrow, while thinning can initially increase the risk of wind damage to trees, trees can become adapted to their new environment and become more resilient to windthrow. Removal of hazardous or diseased trees that are most likely to fail in high wind events would reduce long-term windthrow risks by allowing the remaining healthy trees to grow larger through release from competition, and this increase in growth would occur through diameter growth more than height growth. The remaining healthy trees would be more robust to windthrow. The proposed management actions may lead to a conversion in species composition (e.g. through planting) that adds species that are more robust (e.g. coast live oak, bay laurel) or less robust (e.g. Monterey cypress, Monterey pine) to windthrow. Due to the presumed long-term resiliency to windthrow, this impact is considered less than significant.

**Mitigation:** None required.

**Impact WIND-3: The project could have a substantial adverse effect on wind environments in local neighborhoods. (Less than Significant)**

The Reserve serves as a windbreak to many of the neighborhoods surrounding it, and the removal of trees under the Proposed Management Activities has the potential to increase wind speeds in the neighborhoods. Wind speed effects would depend on a number of factors that include wind gust direction, wind velocity, the configuration of the Reserve and local neighborhoods, and the local topography. Wind gusts perpendicular to the thinned forest may cause houses on the leeward side of a portion of thinned forest to experience increased wind velocity. Wind gusts that are parallel to the forest would not result in a noticeable difference in wind velocity. Higher wind velocities would be expected to result in greater impacts on the local neighborhoods.

The regional climate data indicate that the strongest wind gusts observed at the San Francisco Airport occur during fall and winter (October- March) and their direction is from the south as shown in Table 4.11-2. If such events also derived from the south in the Mount Sutro area,

neighborhoods to the leeward side of the Reserve would be Woodland Avenue, Edgewood Avenue, Koret Way, UCSF Parnassus campus, and Willard Street. During spring and summer months (April-September), the peak gusts at the San Francisco Airport are consistently lower and derive from the west or northwest. During these events, neighborhoods to the leeward side of the Reserve would be Woodhaven Court, Christopher Drive, Clarendon Avenue, and Forest Knolls Drive (to the south), and again, Belmont Avenue, Edgewood Avenue, Woodland Avenue (to the east). Although these are the peak gust directional patterns observed at the San Francisco Airport, strong wind gusts could emanate from any direction in any season. If large storm events derive from the north, the same neighborhoods south of the Reserve would to the leeward side of the Reserve and from the west. The Stanyan Street and Belgrave Avenue neighborhoods would be to the leeward side of the Reserve. Some portions of Christopher Drive have only a small width of trees to serve as a windbreak if the wind direction is from the west. These areas may be more susceptible than areas with a thicker windbreak.

Wind stations discussed in Section 4.11.2.3 did not take measurements in neighborhoods nor did they measure during high wind events. Such measurements are impractical and unnecessary for this analysis, as regional wind speed data discussed in Section 4.11.2.1 Regional Climate - Existing Conditions, combined with the data obtained in the Reserve, are sufficient to inform this analysis. Wind gusts could come from several directions depending on the relative location of storm events to Mount Sutro. The Mount Sutro weather data reveals that topographical differences between the various monitoring stations as well as local obstructions played a strong role and may have overridden any signal produced by differences in tree density.

The proposed project is expected to have a limited impact on the wind environments in select neighborhoods. Based on the dominant wind gust directions from the south (winter) and west/northwest (summer), windbreak effects from trees in the Reserve are likely most significant for the neighborhoods located to the east and north of the Reserve. The literature search suggests that the size of the windbreak provided by the Reserve is large enough (substantially greater than the minimum recommended 300 feet) that the proposed changes in stand density would have limited to no impact on the wind environment in adjacent neighborhoods. Further, trees would not be removed uniformly from all portions of the Reserve. For instance, areas that are too steep, or are inaccessible would not be thinned (UCSF 2010). The following discussion identifies the anticipated effect of the proposed project on each of the neighborhoods surrounding the Reserve.

Thinning in the Reserve could potentially modify the wind environment for the UCSF Medical Center, located to the north of the Reserve, during southerly gusts; however trees directly adjacent to and south of the Medical Center will likely not be thinned due to steep slopes. As a result, the expanse of the Reserve located south of the Medical Center is expected to continue to serve as a windbreak despite some thinning. The wind environment within Edgewood Avenue, Belmont Avenue, and Woodland Avenue (to the northeast of the Reserve) is also not expected to change as a result of the proposed project. In this area, protection from the west is already limited by an existing paved parking lot and a narrow wooded portion of the Reserve. Protection from the south would be unchanged due to the preservation of the Interior Greenbelt open space. The wind environment around Belgrave Avenue and 17th Street (to the east) is also not expected to

change as a result of the proposed project due to preservation of the Interior Greenbelt open space which provides a buffer between the neighborhood and the Reserve. Similarly, the wind environment within the communities to the southeast is not expected to change because the communities are buffered from the Reserve by the Interior Greenbelt open space, the Aldea San Miguel Housing development, and the Summit Reservoir. These three features provide protection from northwesterly winds for the communities located southeast of the Reserve.

Crestmont Drive and Christopher Drive (located immediately south of the Reserve) could be affected by strong north/northeast winds; however, these winds are less common than those originating from other directions. The Reserve extends more than 1200 feet north of these roads, and therefore would still provide protection to these communities even if it was thinned. The wind environment around Crestmont Drive to the west, particularly near the bend just north of Oakhurst Lane, is the area most likely to be affected by proposed project. During east winds, and on rare occasions during late summer and early fall, this neighborhood will be less protected after completion of the proposed project; however these winds are uncommon and would likely only be associated with storm events. In addition, even when thinned, the Reserve is wider than 300 feet at this location and would be expected to function as a modified windbreak for Crestmont Drive upon completion of the proposed project..

Further, the climate data suggests that the neighborhoods most impacted by southerly storms are leeward of sufficient swaths of forest that they would experience little to no change in wind penetration. The same appears to be true for storms that derive from the north or west. This impact would be less than significant.

Based upon the discussion above, the effect of the proposed project on the wind environment in the neighborhoods adjacent to the Reserve would not be significant.

**Mitigation:** None required

## 4.11.6 REFERENCES

Arens, E. 1981. Designing for Acceptable Wind Environment. Transactions Engineering Journal, ASCE 107, No. TE 2. Pages 127–141.

Burns and Honkala.1990. Silvics of North America. USDA US Forest Service. Agricultural Handbook 654.

Cremer, K.W., C.J. Borough, F.H. McKinnell, and P.R. Carter. 1982. Effects of stocking and thinning on wind damage in plantations. N.Z. J.For.Sci. 12:244-268.

Everham, E.M. and Brokaw N.V.L. 1996. Forest damage and recovery from catastrophic wind. Bot. Rev. 62 (2), 113-185.

Foster, D.R. 1988. Disturbance history, community organization, and vegetation dynamics of the old-growth Pisgah forest, southwestern New Hampshire. USA. J. Ecol. 76 (1), 105-134.

Kansas State University, 2004. Windbreaks for Kansas, Kansas Forest Service, Accessed 8/21/2012: http://www.ksre.ksu.edu/library/forst2/mf2120.pdf

Kramer, M.G., A.J. Hansen, M.L. Taper, and E.J. Kissinger. 2001. Abiotic controls on long-term windthrow disturbance and temperate rain forest dynamics in southeastern Alaska. Ecology 82: 2749-2768.

Harris, A.S. 1989. Wind in the forests of southeast Alaska and guides for reducing damage. Gen. Tech. Rep. PNW-244. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 63p.

Hess, G.R. and J.M. Bay. 1994. Environmental Monitoring and Assessment Program. Assessing the Suitability of Windbreaks as Wildlife Habitat. US Environmental Protection Agency, Washington D.C.

HortScience. 1999. Tree survey: Mount Sutro Open Space Reserve maintenance and restoration plan

McBride and Leffingwell. 2006. Assessing windthrow potential in urban forests of coastal California. Society for American Foresters newsletter. Accessed here: http://imap.www.safnet.org/fp/documents/wind_throw_in_urban_forests_06.pdf

Navratil, S. 1995. Minimizing wind damage in alternative silviculture systems in boreal mixed woods. Canadian Forest Service and Land and Forest Service.

National Resources Conservation Service (NRCS). 2012. Custom Soil Resource Report for San Mateo County, Eastern Part and San Francisco County, California. August 27, 2012.

National Oceanic and Atmospheric Administration (NOAA), 2012. National Data Buoy Center. http://www.ndbc.noaa.gov

Ohio State University. 2012. Fact Sheet: Shelterbelts for Wildlife. Accessed 8/21/2012: http://ohioline.osu.edu/w-fact/0016.html

Roberts, S.D, Harrington, C.A., Buermeyer, K.R. 2007. Does variable-density thinning increase wind damage in conifer stands on the Olympic Peninsula? West. J. Appl. For. 22(4) pp 285-296.

Ruel, J.C. 1995. Understanding windthrow: silvicultural implications. For. Chron. 75, 434-445.

Rutherford and Chekene (R & C) 2011. Draft Report. Geotechnical and Geological Evaluation UCSF Mount Sutro Management San Francisco, California. October 12, 2011. #2011-028G.

UCSF. 2010. Notice of Preparation/ Initial Study for EIR. December 10, 2010. Accessible at: http://campusplanning.ucsf.edu/pdf/Initial_Study_UCSF_Mt_Sutro_Mgmt.pdf

Western Regional Climate Center (WRCC), 2012a. Historical Data Summaries. http://www.wrcc.dri.edu

Western Regional Climate Center (WRCC), 2012b. Climate of California. Narratives. http://www.wrcc.dri.edu

White, P.S. and Pickett, S.T.A, 1985. Natural disturbance and patch dynamics: an introduction. In: Pickett, S.T.A., White, P.S. (Eds), Natural disturbance and patch dynamics. San Diego, CA; Academic Press, Inc. pp. 3-13.

Wisconsin Department of Natural Resources, 2003. Windbreaks that work. Accessed 8/21/2012: http://dnr.wi.gov/forestry/publications/pdf/FR-070.pdf

Wonn, H.T. and K.L. O'Hara. 2001. Height: diameter ratios and stability relationships for four northern Rocky Mountain tree species. West. J. Appl. For. 16: 87-94.

# CHAPTER 5

# CEQA STATUTORY SECTIONS

Section 15126 of the *California Environmental Quality Act (CEQA) Guidelines* states that an Environmental Impact Report (EIR) must include a discussion of the following topics:

- Significant environmental effects which cannot be avoided if the proposed project is implemented
- Significant Irreversible Changes which would be caused by the proposed project should it be implemented
- Growth-inducing impacts of the proposed project

In addition, Section 15128 of the *State CEQA Guidelines* requires a brief statement of the reasons that various possible effects of a project have been determined not to be significant and therefore, are not evaluated in the EIR.

The following sections address each of these types of impacts based on the analyses included in **Section 4.0, Environmental Setting, Impacts, and Mitigation Measures**.

## 5.1 SIGNIFICANT AND UNAVOIDABLE ENVIRONMENTAL IMPACTS

As detailed in **Section 4.10**, implementation of the proposed project could result in a significant noise impact that cannot with certainty be mitigated to a less than significant level.

## 5.2 SIGNIFICANT IRREVERSIBLE CHANGES

Section 15126.2(c) of the *State CEQA Guidelines* requires a discussion of the extent to which a proposed project would commit nonrenewable resources to uses that future generations would be unable to reverse. The *State CEQA Guidelines* describe three distinct categories of irreversible changes that should be considered.

### Changes in Land Use which Commit Future Generations

The proposed project would not involve a change in land use. The project site contains a forested open space reserve that The Regents of the University of California has committed remain accessible to the general public. No change to the use of the property is proposed.

### Consumption of Natural, Nonrenewable Resources

Analysis of the degree to which a proposed project would consume nonrenewable resources includes assessments of increased energy consumption, consumption of agricultural lands and loss of access to mining reserves. Completion of the proposed project would irretrievably commit nonrenewable resources during implementation of project activities. Carrying out project activities would include, but would not necessarily be limited to, the use of nonrenewable and limited resources such as gasoline or other fuel to power equipment and vehicles. Limited water consumption may be required for new plantings until they are established. As identified in the Initial Study, the proposed project site contains no areas used for agricultural purposes or designated as agricultural land, nor does it contain any significant mineral deposits. As such, the proposed project would not result in irreversible changes related to the consumption of those types of resources.

### Irreversible Damage from Environmental Accidents

Other than the potential use of herbicides, which is analyzed in this EIR in Section 4.8 Hazards – Herbicide Use and Section 4.9 Hydrology, the proposed project would not involve the use of hazardous materials that could result in significant impacts if accidentally released. As detailed in Section 4.8 and 4.9, the proposed project includes protocols for the safe use and handling of herbicides, as well as mitigation and improvement measures to ensure impacts related to accidental spills are reduced to less than significant levels.

## 5.3 GROWTH-INDUCING IMPACTS

This section evaluates the potential for growth inducement as a result of the proposed project implementation. Section 15126.2(d) of the *State CEQA Guidelines* requires that an EIR include a discussion of the potential for a proposed project to foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment.

The *State CEQA Guidelines* do not provide specific criteria for evaluating growth inducement and state that it must not be assumed that growth in an area is necessarily beneficial, detrimental, or of little significance to the environment. Growth inducement is generally not quantified, but is instead evaluated as either occurring, or not occurring, with implementation of a project. The identification of growth-inducing impacts is generally informational, and mitigation of growth inducement is not required by CEQA. It must be emphasized that the *State CEQA Guidelines* require that an EIR to "discuss the ways" a project could be growth inducing and to "discuss the characteristics of some projects that may encourage…activities that could significantly affect the environment." However, the *State CEQA Guidelines* do not require that an EIR predict or speculate specifically where such growth would occur, in what form it would occur, or when it would occur.

For the purposes of this analysis, the proposed project would be considered growth inducing if it meets either of the following criteria:

- The project removes an obstacle to population growth (for example, through the expansion of public services or utilities into an area that does not presently receive these services), or through the provision of new access to an area, or a change in a restrictive zoning or General Plan land use designation.

- The project causes economic expansion and population growth through employment expansion, and/or the construction of new housing.

Generally, growth-inducing projects are either located in isolated, undeveloped, or underdeveloped areas, necessitating the extension of major infrastructure such as sewer and water facilities or roadways, or are projects that encourage premature or unplanned growth. An evaluation of the proposed project and how it is related to these growth-inducing criteria is provided below.

### Removal of an Obstacle to Population Growth

The proposed project would not remove any obstacle to growth at the Parnassus Heights campus site. The project site has been designated by The Regents an open space reserve, and the project does not propose to change this designation.

### Direct and Indirect Population and Employment Growth

The proposed project would improve public access to the site, but as explained in the Initial Study, the proposed project would not induce substantial population growth in the area, or create a demand for housing.

Carrying out project activities would result in short-term employment that would be filled by the labor force available in the greater Bay Area. In summary, the proposed project would not result in growth inducing impacts.

## 5.4 EFFECTS FOUND NOT TO BE SIGNIFICANT

Section 15128 of the *State CEQA Guidelines* requires an EIR to briefly describe any potential environmental effects that were determined not to be significant during the Initial Study and EIR scoping process and were, therefore, not discussed in detail in the EIR. A discussion of these less than significant effects of the proposed project on aesthetics, agricultural and forestry resources, biological resources, cultural resources, geology and soils, hazards and hazardous materials, land use and planning, mineral resources, noise (except for increased noise level exposure to nearby residents), population and housing, public services, recreation, transportation, and utilities and service systems is presented in the Initial Study which is included in Appendix A. Other impacts found to be less than significant in the EIR are discussed in detail in **Section 4.0, Environmental Setting, Impacts, and Mitigation Measures,** and summarized in **Section 2.0, Executive Summary**.

# CHAPTER 6

# ALTERNATIVES

## 6.1 ALTERNATIVES TO THE PROJECT

The California Environmental Quality Act (CEQA) requires that an Environmental Impact Report (EIR) contain an analysis describing a range of reasonable alternatives to a project that could feasibly attain most of the basic objectives of the project while avoiding or substantially lessening any significant impacts of the proposed project. The analysis must evaluate the comparative merits of the alternatives (*State CEQA Guidelines* Section 15126.6). Alternatives that avoid or substantially reduce significant impacts should be considered, even if these alternatives would impede to some degree the attainment of project objectives or would be more costly to the project proponent (*State CEQA Guidelines* Section 15126.6(b)). The alternatives do not need to consider less than significant impacts identified for the proposed project. An EIR need not consider every conceivable alternative to a project, but rather, it must consider a reasonable range of potentially feasible alternatives that will foster informed decision making and public participation (*State CEQA Guidelines* Section 15126.6(a)).

The analysis in this section is intended to inform the public and decision makers of alternatives to the proposed project and to provide a meaningful evaluation, analysis, and comparison of these alternatives with the proposed project. As required by CEQA, this section also includes an analysis of the No Project alternative.

All of the proposed project's impacts, except the impact of increased noise exposure to adjacent residents in the Edgewood Avenue area, would be less than significant or mitigated to less than significant levels with the adoption of mitigation measures identified in this EIR. In addition, the proposed project would not contribute to potentially significant or significant cumulative impacts.

The focus of this alternatives analysis is to determine whether the alternatives would eliminate the proposed project's single potentially significant impact or further reduce less than significant impacts of the proposed project, and also to determine whether the alternatives would result in a significant impact on a resource area where the proposed project would not result in a significant impact.

This EIR considers the following alternatives:

- No Project Alternative
- Reduced Project Alternative

## Alternatives Considered But Not Evaluated in Detail

An alternative that involved no herbicide use was considered but was determined to be unnecessary to study in this EIR. The University has not yet determined whether herbicides would be used in the Reserve as part of proposed project, other than as prescribed in the Demonstration Projects, and the University has the option to forgo herbicide use if it finds that alternative regrowth control methods are effective.

Further, an analysis of the environmental consequences of not using herbicides would greatly depend on the effectiveness of the alternative methods to herbicides. Clearly, the absence of herbicide use in the Reserve would mean that the less than significant impacts associated with the proposed project with regard to herbicide use would not occur. But if alternatives to herbicides are not effective, other impacts on aesthetics, biological resources, etc. could occur.

Given that the Demonstration Projects are designed in part to test the effectiveness of herbicide use against alternative regrowth control methods, an EIR alternative that involves no herbicide use would not provide any additional useful information for decision makers or practical information for those who would participate in project implementation.

## Project Objectives

As noted in **Section 3.0, Project Description,** the proposed project is needed in order to improve the health of the Reserve and to reduce the risk of a wildfire. The primary objectives of the proposed management actions fall into four broad categories:

- to improve safety
- to enhance the overall health of the Reserve
- to improve its aesthetics
- to increase its usability

The specific objectives of the proposed project, as described in the *UCSF Mount Sutro Open Space Reserve Community Planning Process Summary Report*, November 2010, are:

Safety

- To reduce fuel load and potential for a devastating wildfire
- To provide emergency response access
- To remove hazardous trees near trails, roads and structures
- To improve trailside visibility
- To provide long-term maintenance

Health

- To reduce competition among trees (increase growing space, soil/plant moisture and fertility)
- To remove diseased and unhealthy trees
- To create a variety of tree ages

- To increase tree species diversity
- To remove vines from tree trunks
- To monitor and sustain the health of the forest

Aesthetics

- To maintain a forested setting
- To maintain attractive healthy trees
- To improve visibility within the forest
- To provide views beyond the forest

Usability

- To maintain adequate path and trailside clearance
- To place logs for seating along trails and to close unauthorized trails
- To modify steep trail segments with switchbacks
- To enrich habitat and outdoor experience

### 6.1.1 NO PROJECT ALTERNATIVE

CEQA requires that a "No Project" alternative be considered. Under this alternative, the Demonstration projects would not occur, nor would vegetation management activities throughout the remainder of the Reserve. New trails would not be created. However, ongoing maintenance in the Reserve, an activity exempt from environmental review under CEQA, would continue as it did prior to the project being proposed. As discussed in the Initial Study, ongoing maintenance would include but not necessarily be limited to pruning trees and bushes, removing hazardous trees, removing debris, and restoring trails. Herbicide use would continue in a limited manner, as it did prior to the proposal of the project.

This alternative would not meet any of the project objectives, other than those objectives that relate to ongoing maintenance:

- To remove hazardous trees near trails, roads and structures
- To improve trailside visibility
- To provide long-term maintenance
- To remove diseased and unhealthy trees
- To remove vines from tree trunks
- To maintain adequate path and trailside clearance

#### Aesthetics

With the proposed project, impacts on aesthetics, including on visual character and scenic views, would be less than significant. Following management activities, the Reserve would have less vegetation and appear more open, but would retain its forested setting. Additional trails would provide for more access to views from the Reserve.

Under the No Project Alternative, the forest would continue to decline in health, and therefore in appearance. Competition for light and nutrients would take its toll on the forest. As discussed in the HortScience report,[1] the regeneration and recruitment of eucalyptus into the forest canopy is limited, and little regeneration is occurring even when trees fall and create gaps in the canopy. The rampant growth of English ivy, Himalayan blackberry and other invasive exotic species further impedes regeneration. According to HortScience, without healthy regeneration through proactive management, the forest will continue to decline, and may eventually be overtaken by the invasive understory of shrubs and ivies. This suggests that over time, the No Project Alternative would have a significant adverse impact on the aesthetics and visual quality and visual character of the Reserve. With regard to the proposed trails, the absence of proposed trails would mean less access to the views from the Reserve, however limited, compared to the proposed project. However, the absence of the proposed trails would not result in a significant environmental impact with regard to aesthetics and scenic views.

## Air Quality

The proposed project would involve the use of heavy equipment to carry out proposed management activities. The resulting project impacts on air quality would be less than significant.

With the No Project Alternative, the proposed management activities would not occur and therefore no air quality emissions from heavy equipment use would result. Therefore, air quality impacts under the No Project Alternative would be less than significant, as with the project.

## Biological Resources

The proposed project would result in less than significant impacts on biological resources, with mitigation measures made a condition of project approval.

With the No Project Alternative, the health of the forest would continue to decline, as discussed above. Over time, biodiversity and wildlife habitat would suffer with the spread of invasive understory shrubs and ivies. Therefore, biological resource impacts under the No Project Alternative would be significant.

## Cultural Resources

With regard to cultural resources, project impacts resulting from the implementation of Demonstration project activities, as well as from continued implementation throughout the remainder of the Reserve, would have a less-than-significant impact on the Reserve as a historical resource. The character-defining features of the Reserve that convey its historical significance – the forest whose predominant species is eucalyptus, the trail system and the natural topographic characteristics including rock outrcops -- would not be materially impaired.

[1] UCSF Mount Sutro Open Space Reserve Maintenance and Restoration Plan, July 1999, prepared by HortScience

Under the No Project Alternative, the character-defining features of the Reserve that convey its historical significance would not undergo a substantial adverse change. Over time, the health of the forest would deteriorate, but not likely to the degree that the historic character-defining features of the Reserve would be materially impaired. The trail system would remain as well as the natural topographic features of the site. Therefore, cultural resource impacts under the No Project Alternative would be less than significant.

## Geology and Soils

The proposed project would have a less than significant impact on geology and soils, with a mitigation measure related to the construction of trails made a condition of project approval.

With the No Project Alternative, the health of the forest would continue to decline. The little understory recruitment of eucalyptus saplings and small trees that occurs at present is expected to continue under the No Project Alternative. Root systems that contribute to soil stability could eventually rot, although as discussed in Section 4.5 Geology and Soils, eucalyptus root systems are especially hardy. In addition, although the continued deterioration of the forest could lead to additional erosion, it is unlikely that the deterioration would lead to substantial adverse changes to geology and soils conditions in the short term. Potential long-term effects on geology and soils under the No Project Alternative would be somewhat speculative, and are considered less than significant.

## Greenhouse Gas Emissions

With the proposed project, impacts related to generation of greenhouse gas emissions from temporary equipment operations would be less than significant. With regard to carbon sequestration, forest thinning activities in the short term would be expected to reduce the amount of carbon sequestered in the Reserve. However, over the long term, the net gains in forest health and reduced tree mortality would offset much or all of the carbon loss. Therefore, proposed project impacts with regard to greenhouse gas emissions would be less than significant.

Under the No Project Alternative, forest health would continue to decline, limiting the ability of the forest to sequester carbon. The little understory recruitment of eucalyptus saplings and small trees that occurs at present is expected to continue under the No Project Alternative. In the short-term, little to no change would be expected in the amount of sequestered carbon held in the Reserve. However, in the long-term, additional carbon would be lost to the atmosphere. As discussed in Section 4.6 Greenhouse Gas Emissions, young, healthy forests absorb carbon more rapidly than older dense forests. Mature eucalyptus are well past peak growth and are no longer sequestering much, if any, additional carbon. As less recruitment into the understory is projected for the No Project Alternative compared to the proposed project, less carbon sequestration would be expected under the No Project Alternative compared to the proposed project. The amount of carbon sequestration loss under the No Project Alternative has not been determined. As the significance of the long-term impact on greenhouse gas emissions under the No Project Alternative is somewhat speculative, the impact is considered less than significant.

## Hazards – Fire Hazards

Impacts of the proposed project in regard to fire hazards would be less than significant.

Under the No Project Alternative, continued deterioration of the forest and continued tree mortality would lead to increased fuel loads. As such, compared to the proposed project, the No Project Alternative would have a greater risk of wildfire. However, that increased risk would not result in a significant impact when viewed against existing conditions.

## Hazards – Herbicide Use

The proposed project would have less than significant impacts with regard to herbicide use, with herbicide use protocols included in the project as proposed and with mitigation measures made a condition of project approval.

Under the No Project Alternative, ongoing maintenance in the Reserve, including the limited use of herbicides, would continue as it did prior to the proposal of the project. No significant impact would occur provided the University carries out the same herbicide use protocols and mitigation measures as identified for the proposed project.

## Hydrology

The proposed project would have less than significant impacts on hydrology and water quality, with mitigation measures made a condition of project approval.

Under the No Project Alternative, hydrology and water quality conditions would not be expected to change substantially. As discussed above under Geology and Soils, additional erosion could occur in the Reserve with the further decline in forest health. However, such changes would not be significant. Accordingly, changes in water runoff patterns or quantities of runoff would not be expected to change substantially.

Under the No Project Alternative water quality impacts would be less than significant, provided UCSF carries out the same water quality mitigation measures associated with herbicide use identified for the proposed project.

For the reasons stated, hydrology and water quality impacts under the No Project Alternative would not be significant.

## Noise

With the proposed project, exposure of nearby residents along Edgewood Avenue to additional noise in excess of the ambient noise reduction goal of 50/55 dBA would be significant and unavoidable. A mitigation measure has been identified to limit the amount of vegetation removed near the Edgewood Avenue properties, consider new planting requests, and continue ongoing efforts to reduce ambient noise levels through replacement and upgrade of campus

rooftop mechanical equipment. However, the mitigation measure cannot guarantee that exposure to excess noise levels would be reduced to less than significant levels. Therefore, the impact is significant and unavoidable.

With the No Project Alternative, proposed management activities would not be implemented. Therefore, Edgewood Avenue residents would not be exposed to additional excess noise and this impact would be less than significant.

### Wind

The proposed project would have less than significant impacts with regard to the wind environment and windthrow, with a mitigation measure to provide for ongoing monitoring for signs of potential windthrow hazards in the short term made a condition of project approval. In the long term, trees can become adapted to their new environment and become more resilient to windthrow. Therefore long term impacts with regard to windthrow would be less than significant.

Under the No Project Alternative, as the forest declines in health and as trees weaken, the potential for windthrow would be expected to be greater than with the proposed project. However, the hazards associated with such impacts could be mitigated, as with the proposed project, with ongoing monitoring.

For the reasons stated, wind impacts associated with the No Project Alternative would be less than significant.

### Summary

The No Project Alternative would avoid the significant unavoidable impact of the proposed project regarding increase noise exposure. However, the No Project Alternative would have significant impacts that the proposed project would not have, such as impacts related to aesthetics and biological resources.

The No Project Alternative would not meet any of the project objectives, other than those objectives related to ongoing maintenance, activities which are exempt from environmental review under CEQA.

## 6.1.2 REDUCED PROJECT ALTERNATIVE

Under the Reduced Project Alternative, forest-thinning and understory removal activities would be scaled back to roughly half the amount desired by UCSF (i.e. tree-spacing at roughly 15 feet on average between tree trunks instead of 30 feet, and understory removal of about 45% instead of 90%). Select tree and vegetation removals to create views from the Reserve would be included in this Alternative. Trails would be constructed as with the proposed project. In addition, herbicide use is assumed to occur as with the proposed project. However, no management activities would occur within the area adjacent to the Edgewood Avenue properties.

This alternative would partially meet the project objectives, but not at the scope and scale that UCSF desires.

## Aesthetics

With the proposed project, impacts on aesthetics, including on visual character and scenic views, would be less than significant. Following management activities, the Reserve would have less vegetation and appear more open, but would retain its forested setting. Additional trails would provide for more access to views from the Reserve.

Under the Reduced Project Alternative, some improvement in the health of the Reserve can be expected compared to existing conditions, though not to the degree anticipated with the proposed project. Because the existing decline in forest health and appearance would be addressed to some degree with the Reduced Project Alternative, impacts with regard to aesthetics would be less than significant.

## Air Quality

The proposed project would involve the use of heavy equipment to carry out proposed management activities. The resulting project impacts on air quality would be less than significant.

With the Reduced Project Alternative, the management activities would similarly require the use of heavy equipment. However, the duration of use would likely be less given the reduced amount of tree/vegetation removals compared to the proposed project. Like the proposed project, the Reduced Project Alternative would result in less than significant impacts on air quality.

## Biological Resources

The proposed project would result in less than significant impacts on biological resources, with mitigation measures made a condition of project approval.

With the Reduced Project Alternative, some improvement in the health of the Reserve can be expected compared to existing conditions, though not to the degree anticipated with the proposed project. Because the existing decline in forest health and its habitat values would be addressed to some degree with the Reduced Project Alternative, impacts with regard to biological resources would be less than significant, provided the biological resource mitigation measures identified for the proposed project would be carried out under the Reduced Project Alternative.

## Cultural Resources

With regard to cultural resources, project impacts resulting from the implementation of Demonstration project activities, as well as from continued implementation throughout the

remainder of the Reserve, would have a less-than-significant impact on the Reserve as a historical resource. The character-defining features of the Reserve that convey its historical significance – the forest whose predominant species is eucalyptus, the trail system and the natural topographic characteristics including rock outrcops -- would not be materially impaired.

Under the Reduced Project Alternative, the character-defining features of the Reserve that convey its historical significance are likely to be improved upon compared to existing conditions, as with the proposed project. The health of the forest would improve, although not to the degree as with the proposed project. The trail system would be enhanced with the construction of new trails. The natural topographic features would remain unaltered, but may be more visible with forest thinning activities. Therefore, cultural resources impacts under the Reduced Project Alternative would be less than significant,.

## Geology and Soils

The proposed project would have a less than significant impact on geology and soils, with a mitigation measure related to the construction of trails made a condition of project approval.

With the Reduced Project Alternative, impacts on geology and soils would likewise be less than significant, as with the proposed project, with the mitigation measure related to the construction of trails made a condition of project approval.

## Greenhouse Gas Emissions

With the proposed project, impacts related to generation of greenhouse gas emissions from temporary equipment operations would be less than significant. With regard to carbon sequestration, forest thinning activities in the short term would be expected to reduce the amount of carbon sequestered in the Reserve. However, over the long term, the net gains in forest health and reduced tree mortality would offset much or all of the carbon loss. Therefore, proposed project impacts with regard to greenhouse gas emissions would be less than significant.

With the Reduced Project Alternative, impacts on greenhouse gas emissions would be less than significant as with the proposed project. In the short term, forest thinning activities would reduce the amount of carbon sequestered in the Reserve, although not reduced as much as the proposed project given the lesser degree to which trees/vegetation would be removed. In the long term, net gains would similarly be expected to offset much or all of the carbon loss under the Reduced Project Alternative. Therefore, Reduced Project Alternative impacts with regard to greenhouse gas emissions would be less than significant.

## Hazards – Fire Hazards

Impacts of the proposed project in regard to fire hazards would be less than significant.

Under the Reduced Project Alternative, some improvement in the health of the Reserve can be expected compared to existing conditions. Accordingly, the amount of fuel in the Reserve can be

expected to be reduced compared to existing conditions, and therefore the risk of wildfire would be reduced, though not to the degree anticipated with the proposed project. Impacts of the Reduced Project Alternative with regard to fire hazards would be less than significant.

## Hazards – Herbicide Use

The proposed project would have less than significant impacts with regard to herbicide use, with herbicide use protocols included in the project as proposed and with mitigation measures made a condition of project approval.

Under the Reduced Project Alternative, herbicide use would occur as with the proposed project. Thus, impacts of the Reduced Project Alternative would be expected to be the same or similar as with the proposed project, provided the same herbicide use protocols are included in the Reduced Project Alternative and the same mitigation measures are made a condition of the Reduced Project Alternative approval.

## Hydrology

The proposed project would have less than significant impacts on hydrology and water quality, with a mitigation measure to address herbicide use impacts on water quality made a condition of project approval.

Under the Reduced Project Alternative, hydrology and water quality impacts would likewise be less than significant, with a mitigation measure to address herbicide use impacts on water quality made a condition of project approval.

## Noise

With the proposed project, exposure of nearby residents along Edgewood Avenue to additional noise in excess of the ambient noise reduction goal of 50/55 dBA would be significant and unavoidable. A mitigation measure has been identified to limit the amount of vegetation removed near the Edgewood Avenue properties, consider new planting requests, and continue ongoing efforts to reduce ambient noise levels through replacement and upgrade of campus rooftop mechanical equipment. However, the mitigation measure cannot guarantee that exposure to excess noise levels would be reduced to less than significant levels. Therefore, the impact is significant and unavoidable.

With the Reduced Project Alternative, proposed management activities would not be implemented in the area adjacent to Edgewood Avenue residences. Therefore, Edgewood Avenue residents would not be exposed to additional excess noise and this impact would be less than significant under the Reduced Project Alternative.

### Wind

The proposed project would have less than significant impacts with regard to the wind environment and windthrow, with a mitigation measure to provide for ongoing monitoring for signs of potential windthrow hazards in the short term made a condition of project approval. In the long term, trees can become adapted to their new environment and become more resilient to windthrow. Therefore long term impacts with regard to windthrow would be less than significant.

Under the Reduced Project Alternative, wind impacts would be expected to be less than with the proposed project, given the lesser amount of tree/vegetation removals with the Reduced Project Alternative. Nonetheless, the Reduced Project Alternative would result in some risk of windthrow in the short term. The impact would be reduced to less than significant levels with the same mitigation measure identified for the proposed project to conduct monitoring for risk of windthrow hazards. In the long term, windthrow risk under the Reduced Project Alternative would be less than significant, as with the proposed project.

### Summary

The Reduced Project Alternative would avoid the significant unavoidable impact of the proposed project regarding increased noise exposure to adjacent residents. Less than significant impacts of the Reduced Project Alternative would be somewhat less than the impacts of the proposed project, provided mitigation measures are made a condition of the Reduced Project Alternative approval as discussed above.

The Reduced Project Alternative would partially meet the project objectives, but not at the scope and scale that UCSF desires.

## 6.1.3 ENVIRONMENTALLY SUPERIOR ALTERNATIVE

An EIR is required to identify the environmentally superior alternative—that is, the alternative having the fewest significant environmental impacts—from among the alternatives evaluated. The environmentally superior alternative among those evaluated within this EIR is the Reduced Project Alternative, for the reason that the Reduced Project Alternative would not have the significant unavoidable effect of increased noise exposure to adjacent residents in the Edgewood Avenue area that the proposed project would have.

# CHAPTER 7

# REPORT PREPARATION

## 7.1 REPORT AUTHORS

### LEAD AGENCY

The University of California

Susan Desmond-Hellmann, MD, MPH, Chancellor
Arthur and Toni Rembe Rock Distinguished Professor
University of California, San Francisco

### AUTHORS

University of California, San Francisco

John Plotts, Senior Vice Chancellor, Finance and Administration
Lori Yamauchi, Assistant Vice Chancellor, Campus Planning
Kevin Beauchamp, Director, Physical Planning
Diane Wong, Senior Planner
Tammy Chan, Senior Planner
Paul Franke, Assistant Planner

University of California, Office of the President
Charlotte Strem, Assistant Director, Physical & Environmental Planning
Mary O'Keefe, Senior Planner

University of California, Office of General Counsel
Elisabeth Gunther, University Counsel

Legal Counsel
Charles Olson, Esq., Stein & Lubin

# CONSULTANTS

| | |
|---|---|
| Biological Resources: | LSA Associates, Inc. |
| Cultural Resources: | Denise Bradley, ASLA, and Knapp & VerPlanck Preservation Architects |
| Geology and Soils: | Rutherford & Chekene Consulting Engineers |
| Greenhouse Gas Emissions: | URS Corporation |
| Hazards – Herbicide Use: | Leonard Charles & Associates Inc, and Pesticide Research Institute |
| Hydrology: | Clearwater Hydrology |
| Noise: | Charles Salter & Associates, Inc. |
| Wind: | URS Corporation |

# APPENDIX A

INITIAL STUDY &
INITIAL STUDY/EIR SCOPING COMMENT LETTERS

University of California
San Francisco

UCSF

**Campus Planning**

# NOTICE OF PREPARATION / INITIAL STUDY

## University of California San Francisco

## Mount Sutro Management

Lead Agency: The University of California

Prepared by: UCSF Campus Planning
654 Minnesota Street
San Francisco, CA 94143-0286

December 10, 2010

## Organization of the Initial Study

This Initial Study is organized into the following sections:

**Section I – Project Information:** provides information about the proposed project, including project location, lead agency, and contact information.

**Section II –Project Description:** describes the proposed project, the elements included in the project, and the project approvals.

**Section III –Environmental Factors Potentially Affected:** identifies which environmental factors, if any, would be affected by the project, including those that involve at least one significant or potentially significant impact that cannot be reduced to a less than significant level.

**Section IV – Determination:** indicates whether impacts associated with the proposed project are significant, and what, if any, additional environmental documentation is required.

**Section V – Evaluation of Environmental Impacts:** contains the Environmental Checklist form for each resource area. The checklist is used to assist in evaluating the potential environmental impacts of the proposed project. This section also presents an explanation of all checklist answers.

**Section VI – Supporting Information Sources:** lists the references used in the preparation of this document.

**UNIVERSITY OF CALIFORNIA**

**CAMPUS: San Francisco**

## I. PROJECT INFORMATION

1. Project title:

   University of California San Francisco (UCSF) Mount Sutro Management

2. Lead Agency name and address:

   The Regents of the University of California
   1111 Franklin Street
   Oakland, California 94607

3. Contact person and phone number:

   Diane Wong, Environmental Coordinator
   UCSF Campus Planning
   (415) 502-5952
   email: PHEIR@planning.ucsf.edu

4. Project location:

   UCSF Parnassus Heights campus site
   City and County of San Francisco
   Latitude: 37 deg 45 min 29.20 sec North
   Longitude: 122 deg 27 min 27.66 sec West

5. Project sponsor's name and address:

   See contact person listed above.

6. Custodian of the administrative record for this project:

   Same as above.

7. Identification of all applicable LRDP and project EIRs and address where a copy is available for inspection during business hours:

   Not applicable.

# II. PROJECT DESCRIPTION

## A. INTRODUCTION

The University of California, San Francisco ("UCSF") proposes to implement a number of management actions in the UCSF Mount Sutro Open Space Reserve ("Reserve"). The University-owned Reserve is a largely undeveloped 61-acre forest located within UCSF's Parnassus Heights campus site at the center of San Francisco (see Figures 1 and 2). It is surrounded by the UCSF campus -- UCSF's hospital, research, educational and support structures to the north/northwest -- and by urban residential neighborhoods to the south, east and west. In addition, the Interior Greenbelt area, owned by the City of San Francisco, is adjacent to the east side of Reserve. The Reserve, designated as permanent open space by The Regents of the University of California, is open to the public and serves as a point of respite and recreation not only for UCSF, but for the greater community. The primary purposes of the proposed management actions fall into four broad categories: to improve safety, to enhance the overall health of the Reserve, to improve its aesthetics, and to increase its usability.

UCSF has prepared this Initial Study in accordance with the California Environmental Quality Act (CEQA) (California Public Resources Code, Sections 21000-2117) and the Guidelines for Implementation of CEQA (California Code of Regulations, Title 14, Sections 15000-15387). It evaluates potential environmental impacts associated with the proposed management activities across the entire 61-acreReserve, and where appropriate identifies feasible mitigation measures to reduce these potentially significant impacts to a less than significant level.

The purpose of this Initial Study is to provide a preliminary evaluation of the proposed project and to determine upon which environmental topics the project may have a significant adverse effect requiring further analysis in an Environmental Impact Report (EIR). Those environmental topics for which the project would have a "Less than Significant Impact," " Less than Significant Impact with Project Mitigation," or "No Impact," will not be analyzed further in the EIR. "Potentially Significant" environmental impacts of the proposed project will be addressed in detail in the EIR to be prepared for this project.

## B. BACKGROUND

*UCSF Parnassus Heights*

The Parnassus Heights campus site is the oldest and largest, in terms of size and population, of the sites that now comprise UCSF. It is UCSF's institutional center, and houses the Chancellor's office, the offices of the deans of the Schools of Dentistry, Medicine, Nursing and Pharmacy, the Graduate Division, and the chairs of UCSF's academic departments. Parnassus Heights is also the principal location of the UCSF Medical Center, with inpatient facilities at Moffitt/Long Hospitals, the Langley Porter Psychiatric Institute, as well as outpatient facilities and clinics at various locations throughout the campus. The campus also contains research facilities, classrooms, a library, recreation center, student and faculty housing, and various support services.

The slopes of Mount Sutro have limited development of the Parnassus Heights campus to three main areas: The Aldea student housing complex near the summit of Mount Sutro, the Lower Campus shelf at the northern end of the site, and the Woods parcel on the hillside in the center of the site. The Reserve occupies the remaining 61 acres of the campus site. The Reserve is covered by a dense stand of trees, with the exception of the Rotary Meadow at the summit clearing. The Reserve is dominated (82%) by blue gum eucalyptus, planted in the late 1800s. Other tree species include Monterey pine, Monterey cypress, blackwood acacia, and coast redwood. The understory is thick with Himalayan blackberry, other non-native and native shrubs and vines, many of which grow on tree trunks. Though largely undeveloped, the Reserve is adjacent to the main developed portion of the campus and surrounds the UCSF's Aldea Housing complex as well as the Chancellor's residence.

*UCSF Long Range Development Plan (LRDP) and Mount Sutro Open Space Reserve Management Plan*

In 1996, UCSF prepared a Long Range Development Plan (LRDP) to guide the physical development of the campus. The LRDP reaffirmed its commitment to maintain the Reserve as permanent open space and included a proposal to investigate an appropriate maintenance and restoration program for trees and vegetation in the Reserve. To fulfill this proposal, the Mount Sutro Open Space Reserve Management Plan (Plan) was prepared in 2001 to serve as a framework for future management activities. The Plan identified five near-term management actions for the Reserve that could be implemented within approximately ten years (see Figure 3). These near-term activities included:

- hazardous tree removal near buildings and pavement (approximately 18 acres averaging about 15 trees per acre)
- eucalyptus thinning in two demonstration areas (total 2.5 acres)
- conversion planting to native and other appropriate species of trees, shrubs and other plants in eight demonstration areas (total7.6 acres)
- native plant enhancement around three existing known native plant communities
- trail system improvements, including new trails and switchbacks

Under the adaptive management approach discussed in the Management Plan, specific longer-term management actions were to be informed by the evaluation of the near-term management activities and the Reserve's future needs for an additional twenty years. The Management Plan foresaw that the longer-term management activities would include continued expansion of the near-term management actions, specifically:

- incremental eucalyptus thinning elsewhere in the Reserve where trees are particularly dense, except on the western slopes where the terrain is too steep or otherwise inaccessible
- expansion of buckeye, toyon and madrone south of the summit
- expansion of oak woodland mix in the south bowl and planting on the eastern boundary near Edgewood Avenue
- redwood planting on the north-facing slope above the main developed area of the campus
- willow/bay planting in the area along the intermittent creek along the east side of the Reserve

- removal of additional potentially hazardous trees along Medical Center Way to help serve as a fire break.

Since 2001, various activities described in the Management Plan have been implemented, including:

- hazardous tree removal near the Crestmont Avenue and Christopher Drive; along Medical Center Way; near the Surge Building; near Aldea housing and the Chancellor's residence; and along Nike Road
- native plant restoration and enhancement at the summit of Mount Sutro (i.e. the Rotary Meadow)
- screen planting at the Aldea housing complex
- cleared and improved trails, including trail markers
- regular maintenance of the Reserve including pruning and removal of invasive vegetation

Many of these activities were accomplished in large part by the Mount Sutro Stewards, a community-based volunteer organization, in coordination with the UCSF Facilities Management department. These activities were considered maintenance or minor in scope under the California Environmental Quality Act (CEQA) and were exempt from CEQA review.

The 2001 Management Plan is a framework for management of the forest and continues to serve as a guide. However, specific plans for management continue to evolve as priorities change, remnant native plant communities are discovered, and new community members become involved and provide feedback to UCSF. In addition, the health of the forest has declined since the Plan was prepared. As such, the proposed management activities may differ somewhat from those discussed in the 2001 Management Plan. For example, there would be some differences from the Management Plan in the number and sizes of demonstration areas, and in some cases some variation in the types of management actions proposed to occur within specific geographic areas. The overall intent of proposed management activities, however, remains the same: to improve safety, to enhance the overall health of the Reserve, to improve its aesthetics, and to increase its usability. Specific project objectives will be discussed in more detail in the EIR.

### C. PROPOSED PROJECT

The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and plants and conversion to native species). Vegetation management actions are proposed to occur throughout the Reserve over many years and would be phased beginning with four demonstration projects that were crafted with the interested public in the community process described below. The first three demonstration projects are planned to be implemented in the year 2011. The fourth demonstration project would be implemented approximately one year after the first three demonstration projects. Also, a "Hands-Off" management area in which no vegetation management would be undertaken for the one-year duration of the demonstration project timeframe-- is proposed at the request of some community members. The demonstration projects include a range of potential management actions that could be implemented throughout the entire Reserve. Such actions would be

first implemented in these four small areas to "demonstrate" to the public the range of potential results. Public feedback would then inform the University's choices in the management activities to be applied to the remainder of the Reserve. The management actions identified for the demonstration areas are proposed to be applied ultimately beyond the demonstration areas to the remainder of the Reserve, as appropriate, subject to further refinement by UCSF in consultation with the interested public (see Figure 4). Accordingly, this Initial Study and the upcoming EIR analyze impacts resulting from the range of management activities proposed for the entire 61-acre Reserve.

Several principles would be employed while implementing management activities, including:

- Adaptive Management: UCSF is committed to the principle of adaptive management as defined in the 2001 Plan, allowing for public input and opinion and adjustment of management activities before application to other areas of the Reserve.
- Limited Use of Herbicides: Where herbicide use is indicated, targeted spot-application methods would be employed on tree stumps, vine, blackberry and broom stems, and on poison oak adjacent to trails.
- Tree Spacing: Where tree removal is indicated, the priority for removal is dead, dying, unhealthy, and hazardous trees. Where trees must be removed to achieve desired spacing, the next priority would be trees smaller than 12 inches in diameter.

The proposed management activities are as follows:

## Demonstration Projects

Demonstration Project 1: South Ridge Area – 3 acres

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 30 feet between trunks
- Tree stump treatment: 1 acre – rely on hand maintenance; 1 acre –cover with tarps; 1 acre – apply herbicides
- Sprout control: cut mechanically or use goat grazing 1-2 times per year for 3-5 years in 1 acre where stumps are not tarped or treated with herbicide

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak); islands of brush will be maintained for wildlife
- Spot-treat cut tree vines, blackberry stems and poison oak adjacent to trails with herbicide in 1 acre
- Mow, use goat grazing and/or use herbicides consistent with city standards, annually or every other year for 5 years, depending on rate of re-growth

Demonstration Project 2: Edgewood Avenue Area – 2 acres

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning minimal, mostly acacias. Of those areas to be thinned, remaining trees to average spacing of about 30 feet between trunks, close to the spacing that currently exists in most of this area
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Initially, mow up to 90-100% (excluding native plants)
- Mow and/or use goat grazing annually or every other year for 5 years, depending on rate of re-growth

Demonstration Project 3: North Side of Summit – <0.5 acre

Trees

- Remove trees minimally, only as needed to prevent shading of existing Nootka reed grass area
- Remove trees minimally, only as needed to maintain a clear view corridor to the northeast
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Hand-remove non-native plants from grass area

Demonstration Project 4: East Bowl Corridor – 2 acres

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 60 feet between trunks
- Tree stump treatment and sprout control would depend on outcome of Demonstration Project 1, but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used
- Planting of native shrubs and trees (1 acre irrigated, 1 acre non-irrigated)

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak along trails); large areas of underbrush are expected to be maintained in this demonstration area
- Re-growth control depends on outcome of Demonstration Project 1 but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used (herbicides would not be used if it can be demonstrated in

Demonstration Project 1 that undesirable understory plants can be controlled at a reasonable cost without herbicides.)

"Hands- Off" Management Area: South Ridge Area – 2 acres

Trees

- No changes to existing trees, except that maintenance will be performed to remove and prune hazardous trees near homes and trails for the safety of residents and visitors and to keep trails clear (including trash pick-up).

Understory

- Understory would remain as is
- Trails would be kept clear, including trash removal

## Continued Implementation

Edgewood Area

Following the completion and assessment of Demonstration Project 2: Edgewood Avenue Area, management actions proposed in Demonstration Project 2 would be selected for application to the remainder of the Edgewood Avenue Area, including the planting of native trees, shrubs and other plants.

Remainder of the Reserve

Following the completion and assessment of the Demonstration Project 1: South Ridge Area, management actions proposed in Demonstration Project 1 would be selected for application to other areas of the Reserve, excluding the other demonstration project areas, and the Rotary Meadow at the summit. This would include the planting of native species and enhancement of existing remnant native plant communities.

Large-scale tree thinning and understory control would be phased, likely over the course of many years as funding becomes available. It is anticipated that no more than about one-quarter of the Reserve would receive large-scale tree-thinning and understory control treatment at any given time, likely separated by several years before another section of the Reserve is to receive such treatment. Steep slopes of the Reserve that are inaccessible by heavy equipment (about 15 acres of the 61-acre forest) would not receive tree thinning treatment, though some understory control may be implemented if accessible by foot and if use of hand-tools would be effective.

Following the completion and assessment of Demonstration Project 3: North Side of Summit, management actions proposed in Demonstration Project 3 would be selected for application to other areas of the Reserve, such as select tree removal to create views.

After completion and assessment of Demonstration Project 4: East Bowl Corridor, conversion planting would occur in the Reserve as identified in the 2001 Management Plan: on the summit, in the South

Ridge, and in the East Bowl areas (in and around Demonstration Project 4), although not necessarily with all the same species identified in the management plan.

### Trails

Over the past several years, trails have been restored and enhanced to improve access throughout the Reserve for the enjoyment of visitors. For example, an historic trail that was only recently discovered was restored by the Mount Sutro Stewards. Three new trails are proposed as part of the project: (1) a trail on the north side of the Reserve connecting the Historic Trail to the campus, allowing for ease of access to/from the campus; (2) a trail connecting the South Ridge Trail to Christopher Drive, allowing for easier public access from the south side of the Reserve; and (3) an extension of this new trail to Clarendon Avenue and to trails to the Interior Greenbelt (on City-owned land) and southeast of the Reserve (see Figure 5). The creation of these new trails will require minimal vegetation removal, minor amounts of grading and new trail markers.

### Ongoing Maintenance

The University, with the assistance of the UCSF Mount Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees, and restoring trails. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

**UCSF LRDP Mitigation Measures Included in the Project:** The following LRDP mitigation measures are included in and made part of the proposed project.

*Mitigation Measure #1: Archaeological Resources:* Grading and soil disturbance associated with the proposed project could cause substantial adverse changes to archaeological resources at the project site. In the event that any prehistoric or historic subsurface cultural resources are discovered during ground disturbing activities, all work within 100 feet of the resources shall be halted and UCSF shall consult a qualified archaeologist/paleontologist to assess the significance of the find. If any find is determined to be significant and will be adversely affected by the project, representatives of UCSF and the qualified archaeologist/paleontologist would meet to determine the appropriate avoidance measures or other appropriate mitigation. All significant cultural materials recovered shall be subject to scientific analysis, professional museum curation, and documented by the qualified professional. If the discovery includes human remains, CEQA Guidelines 15064.5 (e)(1) shall be followed. In the event of the accidental discovery or recognition of any human remains in any location other than a dedicated cemetery, steps to be taken include:

> (1) There shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until:
> (A) The coroner of the county in which the remains are discovered must be contacted to determine that no investigation of the cause of death is required, and
> (B) If the coroner determines the remains to be Native American: i) The coroner shall contact the Native American Heritage Commission within 24 hours. ii) The Native American Heritage Commission shall identify the person or persons it believes to be the most likely descended from the deceased Native American. iii) The most likely descendent may make recommendations to the landowner or the person responsible for the excavation work, for means of treating or

disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in Public Resources Code Section 5097.98, or

(2) Where the following conditions occur, the landowner or his authorized representative shall rebury the Native American human remains and associated grave goods with appropriate dignity on the property in a location not subject to further subsurface disturbance.
(A) The Native American Heritage Commission is unable to identify a most likely descendent or the most likely descendent failed to make a recommendation within 24 hours after being notified by the commission.
(B) The descendant identified fails to make a recommendation; or
(C) The landowner or his authorized representative rejects the recommendation of the descendant, and the mediation by the Native American Heritage Commission fails to provide measures acceptable to the landowner.

*Mitigation Measure #2: Construction Noise*: Use of heavy equipment for management activities would, on a temporary basis, elevate noise levels in and around the project site, and particularly at nearby sensitive receptors. UCSF shall require contractors to minimize construction noise impacts by use of proper equipment and work scheduling. Construction hours shall be limited to the following schedule:

- Monday through Friday, 7 a.m. to 5 p.m. for not noisy work (80 decibels or less at 100 feet)
- Monday through Friday, 8 a.m. to 5 p.m. for noisy work (more than 80 decibels at 100 feet)
- Extended hours only with advanced notice from the UCSF project manager (Monday through Friday, 5 p.m. to 8 p.m.; Saturday 7 a.m. to 8 p.m.; and Sunday 8 a.m. to 4:30 p.m.)
- No noisy work on Saturdays and Sundays.

## D. DISCRETIONARY APPROVALS

Action by The Regents (including any Regents-delegated committee or official): Upon certification of the EIR, The Regents or its designee will consider whether to approve the proposed management actions.

Action by Other Agencies: There are no responsible agencies that have approval authority over the proposed project. Trustee agencies include the California Department of Fish and Game.

**Figure 1: UCSF Campus Sites**
**Project Site – Parnassus Heights**

**Figure 2: Mount Sutro Open Space Reserve**

**Figure 3: 2001 Management Plan, 10-Year Management Actions**

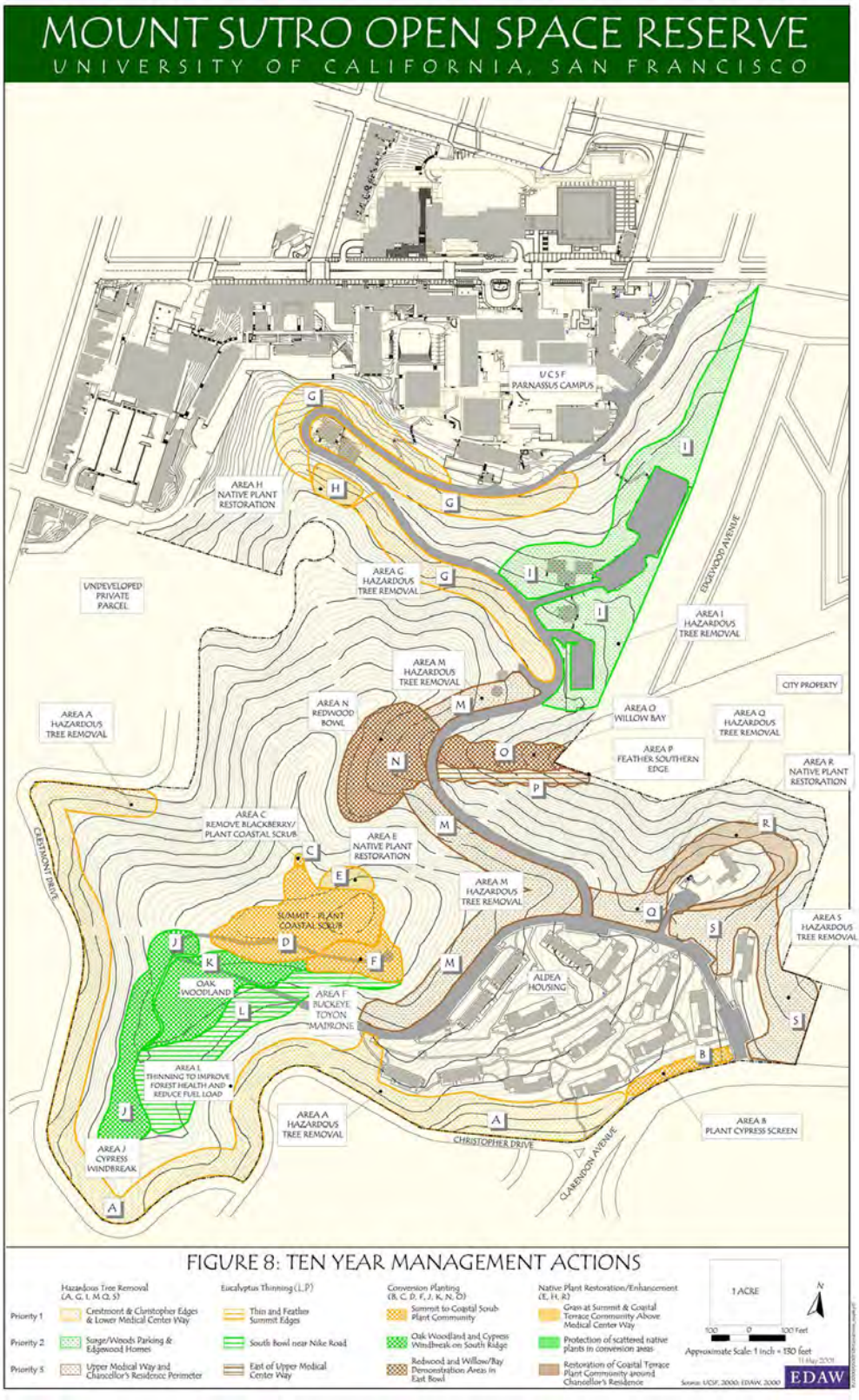
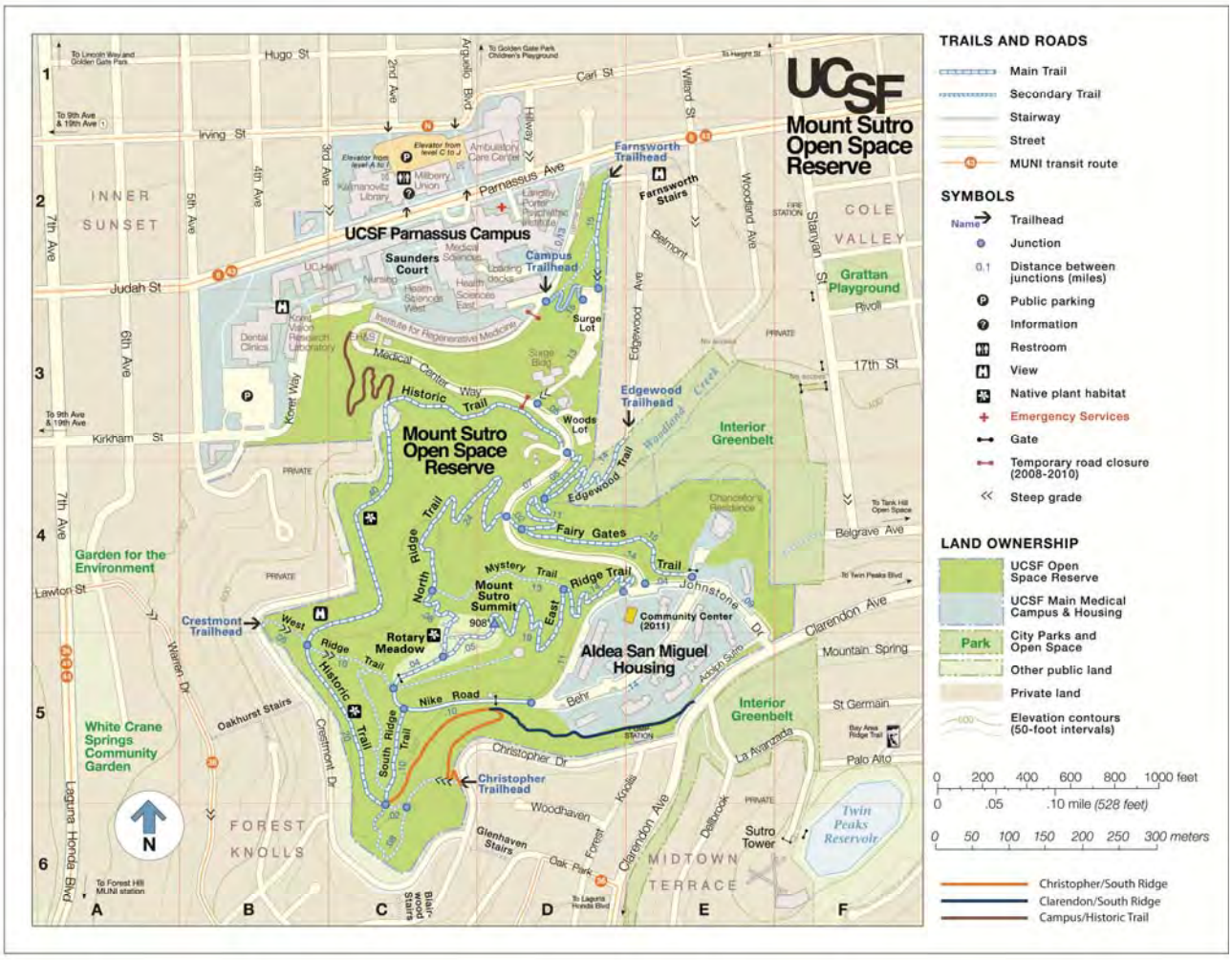


**Figure 4: Proposed Demonstration Project Areas**

## Figure 5: Proposed Trails



## III. ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:

The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Potentially Significant Impact" as indicated by the checklist on the following pages.

| | | |
|---|---|---|
| ■ Aesthetics | □ Agriculture and Forestry Resources | ■ Air Quality |
| ■ Biological Resources | ■ Cultural Resources | ■ Geology/Soils |
| ■ Greenhouse Gas Emissions | ■ Hazards & Hazardous Materials | □ Hydrology/Water Quality |
| □ Land Use/Planning | □ Mineral Resources | ■ Noise |
| □ Population/Housing | □ Public Services | □ Recreation |
| □ Transportation/Traffic | □ Utilities/Service Systems | ■ Mandatory Findings of Significance |

## IV. DETERMINATION: (To be completed by the Lead Agency)

On the basis of the initial evaluation that follows:

□ I find that the proposed project WOULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

□ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made that will avoid or reduce any potential significant effects to a less than significant level. A MITIGATED NEGATIVE DECLARATION will be prepared.

■ I find that the proposed project MAY have a significant effect on the environment. An ENVIRONMENTAL IMPACT REPORT will be prepared.

Diane Wong, Environmental Coordinator
University of California, San Francisco

12/10/10
Date

## V. EVALUATION OF ENVIRONMENTAL IMPACTS

During the completion of the environmental evaluation, the lead agency relied on the following categories of impact noted as column headings in the IS checklist:

A) "Potentially Significant Impact" is appropriate if there is substantial evidence that the project's effect may be significant. If there are one or more "Potentially Significant Impacts" a Project EIR will be prepared.

B) "Less Than Significant With Project Mitigation" applies where the incorporation of project specific mitigation measures will reduce an effect from "Potentially Significant Impact" to a "Less Than Significant Impact." All mitigation measures must be described, including a brief explanation of how the measures reduce the effect to a less than significant level.

C) "Less Than Significant Impact" applies where the project will not result in any significant effects. The project impact is less than significant without the incorporation of mitigation.

D) "No Impact" applies where a project would not result in any impact in the category or the category does not apply. "No Impact" answers need to be adequately supported by the information sources cited, which show that the impact does not apply to projects like the one involved (*e.g.*, the project falls outside a fault rupture zone). A "No Impact" answer should be explained where it is based on project-specific factors as well as general standards (*e.g.*, the project will not expose sensitive receptors to pollutants, based on a project specific screening analysis).

## Impact Questions and Responses

The impact questions identified in this Section are the same as those in Appendix G of the CEQA Guidelines. Additionally, in several impact topics there are impact questions that relate to significance standards established in UCSF's Long Range Development Plan Final EIR, where they are not otherwise covered by Appendix G.

The impact questions consist of two types: those that require a qualitative evaluation, and those that require a quantitative analysis. In general, the impact questions themselves constitute the standards of significance, and where applicable, additional explanation and/or quantitative thresholds are provided under the appropriate environmental topic.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 1. **AESTHETICS –** Would the project**:** | | | | |
| a) Have a substantial adverse effect on a scenic vista? | ■ | ☐ | ☐ | ☐ |
| b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway? | ☐ | ☐ | ☐ | ■ |
| c) Substantially degrade the existing visual character or quality of the site and its surroundings? | ■ | ☐ | ☐ | ☐ |
| d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area? | ☐ | ☐ | ■ | ☐ |
| e) Exceed the LRDP EIR significance standard by substantially reducing sunlight or significantly increasing shadows in public open space areas, or by increasing pedestrian-level wind speeds above the hazard level set forth in the San Francisco Planning Code? | ☐ | ☐ | ■ | ☐ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic.

**Discussion of Checklist Questions**

1a) A scenic vista is defined as a public view from existing parks, plazas, major roadways or other public areas, and gateway or panoramic views from areas generally available to the general public. Views from private residences and non-public access are not considered to be scenic views because they are not available to the general public.

The proposed project would include forest thinning over time, as well as other management activities that may affect the appearance of Mount Sutro as viewed from existing parks, major roadways, etc. In addition, the project includes the creation of public views/vistas from within Mount Sutro looking outward toward other parts of San Francisco and beyond. Therefore, the proposed project's effect on scenic vistas will be evaluated in the EIR.

1b) Nearby designated State Scenic Highways include Interstate 280 (I-280) and State Route 35 (SR 35). Mount Sutro is not visible from I-280, as the nearest segment of I-280 is approximately 2 miles south of the project site. Nor is Mount Sutro visible from SR 35, the closest segment of which ends at 19th Avenue and Sloat Boulevard. Because the proposed project would not create a significant impact on natural or historic resources within a State Scenic Highway corridor, effects on scenic highways will not be evaluated in the EIR.

1c) The proposed project, as discussed in 1a above, could affect the appearance of Mount Sutro, and could impact the visual character or quality of the site. Therefore, this topic will be evaluated in the EIR.

1d) A portion of the project site, the Edgewood area, is located between a row of residences to the east fronting Edgewood Avenue and campus buildings to the west, including Moffitt/Long hospitals and the central utility plant. Currently, vegetation and trees within the Edgewood area provide some visual screening of campus buildings from the rear yards of these residences, including possibly screening of light sources from the campus at night. Proposed vegetation management activities have the potential to reduce this visual screen. However, such impacts on adjacent private residences would not constitute a significant impact on day or nighttime views in the area. Therefore, light and glare impacts resulting from the proposed project will not be analyzed in the EIR.

1e) The project primarily involves thinning of the Reserve, removal of understory vegetation, conversion planting, native plant enhancement, and creation of new trails. The pedestrian-level wind speed hazard criterion set forth in the San Francisco Planning Code applies to new buildings generally 100 feet in height or taller in certain zoning districts, and as such would not apply as a significance standard to the proposed project. Nonetheless, proposed management activities are not expected to create hazardous winds.

Winds in San Francisco predominantly come from the west and northwest. In general, increases in wind speeds may occur when winds are intercepted by a large plane, such as a dense stand of trees, and are redirected. Thus, a permeable stand of trees may be more effective in functioning as a wind break than a dense stand of trees. With a proposed average spacing of about 30 feet between trees for much of the Reserve, proposed management activities would not be sufficient to greatly affect the pedestrian-level wind environment. Over time, as tree canopies expand, wind speeds would tend to be reduced. Thus, the proposed project would not expose persons or adjacent properties to substantially increased wind speeds. Thinning a narrow stand of trees may result in increased exposure to existing winds that may be noticeable to some people, but such effects would not be considered significant. For the reasons noted,

wind impacts would be less than significant and will not be analyzed in the EIR.

The proposed project would involve forest thinning and removal of understory vegetation, and therefore would enable greater sunlight exposure within the Reserve. Sunlight and shadow impacts would be less than significant and will not be analyzed in the EIR.

| Issues | Potentially Significant Impact | Less Than Significant with Mitigation Incorporated | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 2. **AGRICULTURE AND FORESTRY RESOURCES** – In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board. Would the project: | | | | |
| a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use? | ☐ | ☐ | ☐ | ■ |
| b) Conflict with existing zoning for agricultural use, or a Williamson Act contract? | ☐ | ☐ | ☐ | ■ |
| c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)) or timberland (as defined in Public Resources Code section 4526)? | ☐ | ☐ | ☐ | ■ |
| d) Result in the loss of forest land or conversion of forest land to non-forest use? | ☐ | ☐ | ☐ | ■ |
| e) Involve other changes in the existing environment, which, due to their location or nature, could result in conversion of Farmland to non-agricultural use? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP or Program EIR significance standards.

**Discussion of Checklist Questions**

2 a), b), &e) The Mount Sutro Open Space Reserve contains no agricultural uses. Therefore, no study of agricultural resources is necessary, and this topic will not be evaluated further in the EIR.

2c) & d) The project does not propose rezoning, loss of forest land, or conversion of forest land to non-forest use. This topic will not be analyzed in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 3. **AIR QUALITY –** Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project**:** | | | | |
| a) Conflict with or obstruct implementation of the applicable air quality plan? | ■ | ☐ | ☐ | ☐ |
| b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation (e.g., induce mobile source carbon monoxide (CO) emissions that would cause a violation of the CO ambient air quality standard)? | ■ | ☐ | ☐ | ☐ |
| c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)? | ■ | ☐ | ☐ | ☐ |
| d) Expose sensitive receptors to substantial pollutant concentrations? | ■ | ☐ | ☐ | ☐ |
| e) Create objectionable odors affecting a substantial number of people? | ☐ | ☐ | ■ | ☐ |
| f) Exceed the applicable LRDP EIR standard of significance by exposing receptors to toxic air contaminant emissions that (1) result in a cancer risk greater than 10 cancer cases per 1 million people exposed in a lifetime; or (2) for acute or chronic effects, result in concentrations of toxic air contaminant emissions with a Hazard Index of 1.0 or greater. | ■ | ☐ | ☐ | ☐ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. Regarding standards related to local air district plans under questions b) and c), the significance criteria established by the Bay Area Air Quality Management District (BAAQMD) is used to determine the significance of air quality impacts.

**Discussion of Checklist Questions:**

3 a), b), c), d) & f) The potential effects of the proposed project on air quality will be evaluated in the EIR. Heavy equipment used for management activities could cause temporary air quality impacts. These topics will be evaluated in the EIR.

3e) With respect to creating objectionable odors affecting a substantial number of people, odorous substances are regulated under BAAQMD Regulation 7. This regulation prohibits the emission of odorous compounds which remain odorous after dilution with a specified quantity of odor-free air. Management activities, including the use of heavy equipment, would not involve odorous substances that exceed this regulation. As the project would not result in a substantial adverse effect on odors, this topic will not be evaluated further in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 4. **BIOLOGICAL RESOURCES –** Would the project**:** | | | | |
| a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service? | ■ | ☐ | ☐ | ☐ |
| b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service? | ■ | ☐ | ☐ | ☐ |
| c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means? | ☐ | ☐ | ☐ | ■ |
| d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites? | ■ | ☐ | ☐ | ☐ |
| e) Conflict with any applicable policies protecting biological resources? | ■ | ☐ | ☐ | ☐ |
| f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other applicable habitat conservation plan? | ☐ | ☐ | ☐ | ■ |
| g) Exceed the applicable LRDP EIR standard of significance by damaging or removing heritage or landmark trees or native oak trees of a diameter specified in a local ordinance? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. In addition, the significance standard related to local tree ordinances is used as a basis to evaluate potential heritage or landmark trees at UCSF sites.

**Discussion of Checklist Questions:**

4 a), b), d), e) As a forest management project, proposed activities may impact biological resources, including plants, wildlife, and wildlife habitat. UCSF has retained the services of a biological resource team that will assess and document existing conditions and evaluate the impacts of the proposed project on biological resources relative to the above significance criteria. These topics will be analyzed in the EIR.

4 c), f) There are no federally protected wetlands on the project site, and no adopted habitat conservation plans, natural community conservation plans, or other applicable habitat conservation plan that would be applicable to the project. These topics will not be analyzed in the EIR.

4g) The site does not contain any heritage or landmark trees specified in a local ordinance. This topic will not be analyzed in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 5. **CULTURAL RESOURCES –** Would the project: | | | | |
| a) Cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5? | ■ | ☐ | ☐ | ☐ |
| b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5? | ☐ | ■ | ☐ | ☐ |
| c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature? | ☐ | ☐ | ☐ | ■ |
| d) Disturb any human remains, including those interred outside of formal cemeteries? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP significance standards.

**Discussion of Checklist Questions:**

5 a) The Parnassus Heights campus was undeveloped coastal scrub and oak habitat until construction began in 1864 for Toland Medical College and Adolph Sutro began planting the hill in 1886. The EIR will assess the Mount Sutro Open Space Reserve to determine whether it qualifies as a cultural landscape (i.e. a historical resource) and whether effects of the proposed project on historical resources will be significant.

5 b) The LRDP Amendment #2 – Hospital Replacement EIR determined that the Parnassus Heights site contains no known archaeological resources. Ishi, the last survivor of the native American Yahi tribe, resided in the Anthropology Museum of the University of California Affiliated Colleges (now UCSF) on Parnassus Heights in the early 1900s. He frequented Mount Sutro, where he demonstrated his skills on arrow-making and other aspects of his culture. Tools created by Ishi can be found at the UC Berkeley Phoebe A. Hearst Museum of Anthropology. Because the possibility of encountering archaeological resources while implementing management activities cannot be ruled out, the EIR included a mitigation measure that required work stoppage and investigation of the find in the event of an accidental discovery. In general, soils on Mount Sutro are relatively shallow, underlain by bedrock. Proposed management activities would not involve substantial excavation that would affect subsurface soils. Trees proposed to be removed would be cut at ground surface, leaving stumps and root systems in place. However, the development of new trails may involve minor amounts of grading, and removal of plants and new plantings may require minor surface disturbance of soils. With the mitigation measure

requiring work stoppage and investigation in the unlikely event of accidental discovery of archaeological resources, impacts on archaeological resources would be reduced to less than significant levels and need not be discussed further in the EIR (see Mitigation Measure #1 below).

5 c) – d) The proposed project would not have a substantial adverse effect on paleontological resources or unique geologic features. There are no known paleontological resources on Mount Sutro. However, there are rock outcroppings atop the hill that add to its unique character. No removal or altering of these rock outcroppings is proposed. Therefore, so no significant effect on paleontological resources or unique geologic features would occur. The project site was not historically used as a cemetery or interment location. These topics will not be analyzed further in the EIR.

*Mitigation Measure #1: Archaeological Resources:* Grading and soil disturbance associated with the proposed project could cause substantial adverse changes to archaeological resources at the project site. In the event that any prehistoric or historic subsurface cultural resources are discovered during ground disturbing activities, all work within 100 feet of the resources shall be halted and UCSF shall consult a qualified archaeologist/paleontologist to assess the significance of the find. If any find is determined to be significant and will be adversely affected by the project, representatives of UCSF and the qualified archaeologist/paleontologist would meet to determine the appropriate avoidance measures or other appropriate mitigation. All significant cultural materials recovered shall be subject to scientific analysis, professional museum curation, and documented by the qualified professional. If the discovery includes human remains, CEQA Guidelines 15064.5 (e)(1) shall be followed. In the event of the accidental discovery or recognition of any human remains in any location other than a dedicated cemetery, steps to be taken include:

(1) There shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until:

(A) The coroner of the county in which the remains are discovered must be contacted to determine that no investigation of the cause of death is required, and

(B) If the coroner determines the remains to be Native American: i) The coroner shall contact the Native American Heritage Commission within 24 hours. ii) The Native American Heritage Commission shall identify the person or persons it believes to be the most likely descended from the deceased Native American. iii) The most likely descendent may make recommendations to the landowner or the person responsible for the excavation work, for means of treating or disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in Public Resources Code Section 5097.98, or

(2) Where the following conditions occur, the landowner or his authorized representative shall rebury the Native American human remains and associated grave goods with appropriate dignity on the property in a location not subject to further subsurface disturbance.

(A) The Native American Heritage Commission is unable to identify a most likely descendent or the most likely descendent failed to make a recommendation within 24 hours after being notified by the commission.

(B) The descendant identified fails to make a recommendation; or

(C) The landowner or his authorized representative rejects the recommendation of the descendant, and the mediation by the Native American Heritage Commission fails to provide measures acceptable to the landowner.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 6. **GEOLOGY AND SOILS –** Would the project: | | | | |
| a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: | | | | |
| i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42. | ☐ | ☐ | ☐ | ■ |
| ii) Strong seismic ground shaking? | ☐ | ☐ | ☐ | ■ |
| iii) Seismic-related ground failure, including liquefaction? | ☐ | ☐ | ☐ | ■ |
| iv) Landslides? | ■ | ☐ | ☐ | ☐ |
| b) Result in substantial soil erosion or the loss of topsoil? | ■ | ☐ | ☐ | ☐ |
| c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse? | ☐ | ☐ | ☐ | ■ |
| d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994) (California Building Code), creating substantial risks to life or property? | ☐ | ☐ | ☐ | ■ |
| e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water? | ☐ | ☐ | ☐ | ■ |
| f) Exceed the applicable LRDP EIR standard of significance by exposing people to structural hazards in an existing building rated Poor, or Very Poor, under the University's seismic performance rating system, or substantial nonstructural hazards? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP significance standards.

**Discussion of Checklist Questions:**

6 a) – b) The San Francisco Bay Area contains both active and potentially active faults and is considered a region of high seismic activity. The nearest known active fault is the San Andreas fault, which near San Francisco trends offshore north of Colma, and continues northwest through the Pacific Ocean approximately six miles due west of the Golden Gate Bridge. Like the entire San Francisco Bay Area, the project site is subject to groundshaking in the event of an earthquake. However, the project site is not within an Alquist-Priolo Special Studies zone. Proposed management activities would not affect exposure of persons to strong seismic ground shaking. Nor would the proposed project expose persons to seismic-related ground failure as it is not within a liquefaction zone. Therefore, impacts with respect to exposure of persons to rupture of a known earthquake fault, seismic groundshaking, and seismic-related ground failure would be less than significant, and need not be discussed further in the EIR.

Parnassus Heights is within the City of San Francisco's Special Geologic Study Area for potential ground failure hazards and the California Geologic Survey (CGS) Seismic Hazard Zone for landslides. As discussed previously, ground disturbance would be minor with the proposed project. Nonetheless, the EIR will analyze the potential for the proposed project to result in substantial soil erosion and to expose persons to landslides.

6 c), d) & e) As discussed above, the project site is within an area subject to landslides, which will be analyzed further in the EIR as discussed above under 6a). Soils on the site are not subject to lateral spreading, subsidence, liquefaction, or collapse, and proposed project activities would have no effect on these subject areas. Therefore, impacts regarding these topics would be less than significant and will not be analyzed further in the EIR.

6 f) Proposed management activities would have no effect on the exposure of persons to seismically Poor or Very Poor buildings. Impacts regarding this topic would be less than significant and need not be analyzed further in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 7. **GREENHOUSE GAS EMISSIONS –** Would the project: | | | | |
| a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment? | ■ | ☐ | ☐ | ☐ |
| b) Conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the emissions of greenhouse gases? | ■ | ☐ | ☐ | ☐ |

7a) & b) Proposed vegetation management activities may affect the ability of the Reserve to sequester greenhouse gas. This topic will be analyzed in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 8. **HAZARDS AND HAZARDOUS MATERIALS –** Would the project: | | | | |
| a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials? | ■ | ☐ | ☐ | ☐ |
| b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment? | ☐ | ☐ | ■ | ☐ |
| c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school? | ☐ | ☐ | ☐ | ■ |
| d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment? | ☐ | ☐ | ☐ | ■ |
| e) For a project located within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area? | ☐ | ☐ | ☐ | ■ |
| f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area? | ☐ | ☐ | ☐ | ■ |
| g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan? | ☐ | ☐ | ☐ | ■ |
| h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands? | ■ | ☐ | ☐ | ☐ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP or Program EIR significance standards.

**Discussion of Checklist Questions:**

8a) UCSF has committed to assessing alternatives to herbicide use as part of its demonstration projects. However, the potential use of herbicides in the Reserve as a means of regrowth control remains and cannot be ruled out. Therefore, potential impacts of the use of herbicides among the array of proposed vegetation management actions will be analyzed in the EIR.

Naturally-occurring asbestos may be contained within the rock outcrops on Mount Sutro. The general geologic setting of San Francisco is characterized by bedrock hills bounded by broad valleys. The bedrock consists of consolidated rocks of the Franciscan Complex which generally consists of sandstone, shale, chert, greenstone, and mélange. In certain places, serpentine, an asbestos-containing rock-type, is found within the shale matrix. As identified in the Mount Sutro Open Space Reserve Management Plan (p17), there are many exposed rock outcrops on Mount Sutro of the underlying Franciscan chert. No disturbance of these rock outcrops is proposed. However, some vegetation removal on rock outcrops could occur, and as such the EIR will analyze the potential for asbestos exposure.
8b) - g) Other than the potential use of herbicides which will be analyzed in the EIR, the proposed project would not involve the use of hazardous materials that could result in significant impacts if accidentally released. As such, hazardous emissions within a quarter mile of a school would not occur with the proposed project. The Reserve is not located on a hazardous materials site, nor is it part of an airport land use plan or located within the vicinity of a private airstrip.

Proposed management activities would not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan. Access roads around and through the Reserve would remain unchanged with the proposed project. With proposed new trail segments, pedestrian access would be improved.

Impacts regarding topics 8 b) - g) are less than significant and will not be analyzed further in the EIR.

8h) The express purpose of the project is to improve the health of the forest and to reduce the exposure of persons and property to a forest fire. The impacts of proposed management activities with regard to the potential for a forest fire will be analyzed in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 9. **HYDROLOGY AND WATER QUALITY –** Would the project: | | | | |
| a) Violate any water quality standards or waste discharge requirements? | ☐ | ☐ | ☐ | ■ |
| b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)? | ☐ | ☐ | ☐ | ■ |
| c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on or off site? | ☐ | ☐ | ■ | ☐ |
| d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on or off site? | ☐ | ☐ | ■ | ☐ |
| e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff? | ☐ | ☐ | ■ | ☐ |
| f) Otherwise substantially degrade water quality? | ☐ | ☐ | ☐ | ■ |
| g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map? | ☐ | ☐ | ☐ | ■ |
| h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows? | ☐ | ☐ | ☐ | ■ |

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam? | ☐ | ☐ | ☐ | ■ |
| j) Inundate by seiche, tsunami, or mudflow? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP or Program EIR significance standards.

**Discussion of Checklist Questions:**

9a) - f) Proposed management activities would not alter hydrology or water quality at the site. There are no surface waterbodies or public water supplies in close proximity to Parnassus Heights, and no aquifers or groundwater recharge areas have been specifically identified at this campus site. No known soil or groundwater contamination issues are present. Sewage and stormwater runoff from Parnassus Heights are treated at the Southeast and Oceanside Water Pollution Control Plants. During wet weather, storage capacity at the Southeast Water Pollution Control Plant is sometimes exceeded, resulting in combined sewer overflows (CSOs). Although minor grading would occur for proposed trails, and some ground disturbance would occur in some locations from heavy equipment, trees to be removed would be cut above ground surface and root systems would be left in place. The project does not propose to modify the topography of the site or pave or modify the imperviousness of surface soils. Thus drainage patterns of the site and the amount or speed of surface runoff would not change with the proposed project. No alteration to the course of a stream or river would occur due to the project. These checklist topics will not be analyzed further in the EIR.

As indicated in this Initial Study under #8 Hazards and Hazardous Materials, herbicide use and potential effects on groundwater will be discussed in the EIR under the topic of Hazardous Materials. As indicated under #6 Geology and Soils, the potential for soil erosion will be analyzed in the EIR.

9g) – j) The site is not within a 100-year flood hazard area, or near a levee or dam. Nor is the site within an area with the potential to be inundated by seiche, tsunami, or mudflow. Thus, these checklist topics will not be analyzed further in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 10. **LAND USE AND PLANNING –** Would the project: | | | | |
| a) Physically divide an established community? | ☐ | ☐ | ☐ | ■ |
| b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect? | ☐ | ☐ | ■ | ☐ |
| c) Conflict with any applicable habitat conservation plan or natural community conservation plan? | ☐ | ☐ | ■ | ☐ |
| d) Exceed an applicable LRDP EIR standard of significance by being substantially incompatible with existing land uses, or by substantially conflicting use, density, height and bulk restrictions of local zoning, although UCSF is exempt from such restrictions? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. In addition, as indicated in impact question d), local land use policies are of concern to UCSF planning efforts.

Pursuant to the University of California's constitutional autonomy, development and uses on property owned or controlled by the University in furtherance of the educational mission of the University are not subject to local land use regulation. However, UCSF cooperates with local planning agencies in matters of mutual concern.

**Discussion of Checklist Questions:**

10a) - d) The proposed management activities would take place within an existing open space and would not physically divide an established community. The proposed project would not involve a change in use or create an incompatibility with existing land uses, nor would it conflict with local zoning, which does not regulate forest management.

UCSF's applicable land use plan, the 1996 LRDP, calls for maintaining the Reserve as permanent open space and investigating an appropriate maintenance and restoration program for trees and vegetation in the Reserve. It also calls for improving hiking trails in the Reserve. The proposed project, which seeks to maintain and enhance the Reserve through vegetation management and creation of trails, would be consistent with the LRDP.

The UCSF Mount Sutro Management Plan is the guiding document which forms the basis of proposed

management activities. Although not officially adopted by The Regents, the Plan provides a framework for management actions. Planning for the management of the Reserve has evolved since the plan's publication ten years ago, and continues to evolve as new neighbors and additional community members are welcomed through UCSF's community process to provide valuable input. In addition, the health of the forest has declined since the Plan was prepared. As such, there are some differences between the Plan and what is now proposed. For example, a modest amount of tree thinning is now proposed within the Edgewood Area, just enough to minimize tree hazards and potentially hazardous wildfire conditions. Proposed management activities that are different from the Plan would not constitute a significant land use impact. The proposed project would not conflict with any applicable habitat conservation plan or natural community conservation plan. The City of San Francisco Recreation and Parks Department has developed a Natural Areas 20-Year Management Plan that seeks to restore and enhance its collection of remnant natural open spaces, including the Interior Greenbelt Natural Area abutting UCSF's Mount Sutro Open Space Reserve on its eastern border. Similar to the proposed project, the Natural Areas Plan envisions for the Interior Greenbelt tree removal, trail restoration/new trails, and native plant enhancement. The proposed project would complement plans for the Interior Greenbelt.

As the proposed project would have no significant land use impacts, this topic need not be analyzed further in the EIR.

| Issues | Potentially Significant Impact | Less Than Significant with Mitigation Incorporated | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 11. **MINERAL RESOURCES –** Would the project: | | | | |
| a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state? | ☐ | ☐ | ☐ | ■ |
| b) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP significance standards.

11a) & b) The proposed project site is not in an area of known mineral resources and would not otherwise conflict with mineral resources recovery. Therefore no further study of mineral resources is necessary and this topic will not be analyzed in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 12. **NOISE –** Would the project result in: | | | | |
| a) Exposure of persons to or generation of noise levels in excess of standards established in any applicable plan or noise ordinance, or applicable standards of other agencies? | ■ | ☐ | ☐ | ☐ |
| b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels? | ☐ | ☐ | ☐ | ■ |
| c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project? | ☐ | ☐ | ☐ | ■ |
| d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project (including construction)? | ☐ | ■ | ☐ | ☐ |
| e) For a project located within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels? | ☐ | ☐ | ☐ | ■ |
| f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels? | ☐ | ☐ | ☐ | ■ |
| g) Exceed an applicable LRDP EIR standard of significance by contributing to an increase in average daily noise levels (Ldn) of 3 dB(A) or more at property lines, if ambient noise levels in areas adjacent to proposed development already exceed local noise levels set forth in local general plans or ordinances for such areas based on their use? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. Regarding impact question g), a project could have a significant noise impact if it contributes to an increase in already exceeded noise ordinance levels.

**Discussion of Checklist Questions:**

12a) Mechanical equipment noise is generated by on-campus buildings, and is particularly noticeable near the power plant and Moffitt/Long hospitals on the east side of the campus, near the Edgewood area of the Reserve. The Edgewood area of the Reserve provides a buffer in distance, visibility, and possibly noise between campus buildings and the residences to the east which have rear yards that abut the Reserve. While it is unclear whether and to what extent the trees and vegetation provide a noise buffer for those residences, the EIR will analyze whether significant impacts may result from the modest tree thinning and vegetation removal proposed for the Edgewood area of the Reserve. Other residences along the perimeter of the Reserve are too distant from the power plant and Moffitt/Long hospitals for proposed management actions to affect their noise exposure in a meaningful way.

12b) - g) Proposed management activities would not expose persons to permanent excessive groundborne noise or vibration, or a permanent increase in ambient noise levels. The project would not result in an average daily increase in noise levels of 3 decibels or more at the property line. The site is not included in an airport land use plan, nor is it in the vicinity of a private airstrip. Noise impacts with regard to these checklist topics would be less than significant and will not be analyzed in the EIR.

Potentially, heavy equipment used to carry out management actions could lead to temporary noise and/or vibration, but these impacts are expected to be short-term. Noise in San Francisco is regulated by the San Francisco Noise Ordinance. Although UCSF is not bound by the San Francisco Noise Ordinance, it endeavors to comply. The Noise Ordinance states that powered construction equipment, other than impact tools, must not exceed 80 decibels at 100 feet (Article 20 of the City Police Code, Section 2907a). The Noise Ordinance also prohibits construction work at night from 8:00 p.m. until 7 a.m., if noise from such work would exceed the ambient noise level by 5 decibels at the property line, unless a special permit is authorized by the San Francisco Department of Public Works. While proposed management activities are not "construction" activities and the equipment used to carry out these activities is not construction equipment, the noise impacts of implementing the proposed are analogous to construction noise impacts given that the heavy equipment used in management and their use on a short-term basis are equivalent to construction equipment in the context of this project. Thus, the term "construction noise" is used to refer to this impact.

To minimize construction noise impacts on nearby residences, the following LRDP EIR mitigation measure which exceeds requirements of the San Francisco Noise Ordinance for construction hours, is included in the proposed project. Implementation of this mitigation measure ensures that construction noise impact associated with the use of heavy equipment would be less than significant. Thus, this topic need not be analyzed further in the EIR.

*Mitigation Measure #2: Construction Noise:* Use of heavy equipment for management activities would, on a temporary basis, elevate noise levels in and around the project site, and particularly at nearby sensitive receptors. UCSF shall require contractors to minimize unavoidable construction noise impacts by use of proper equipment and work scheduling. Construction hours shall be limited to the following schedule:

- Monday through Friday, 7 a.m. to 5 p.m. for not noisy work (80 decibels or less at 100 feet)
- Monday through Friday, 8 a.m. to 5 p.m. for noisy work (more than 80 decibels at 100 feet)
- Extended hours only with advanced notice from the UCSF project manager (Monday through Friday, 5 p.m. to 8 p.m.; Saturday 7 a.m. to 8 p.m.; and Sunday 8 a.m. to 4:30 p.m.)
- No noisy work on Saturdays and Sundays.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 13. **POPULATION AND HOUSING** – Would the Project: | | | | |
| a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)? | ☐ | ☐ | ☐ | ■ |
| b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere? | ☐ | ☐ | ☐ | ■ |
| c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere? | ☐ | ☐ | ☐ | ■ |
| d) Exceed an applicable LRDP EIR standard of significance by creating a demand for housing outside the market area where the facilities or site are located? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. Population and housing changes, in and of themselves, are not normally considered to be significant impacts (substantial, adverse impacts on the physical environment) under CEQA, but CEQA does allow inclusion of these effects as indicators and influences on other impacts, such as traffic, public services, and air quality.

**Discussion of Checklist Questions:**

13a) – d) Proposed management activities would not induce substantial population growth in the area, displace substantial number of existing housing displace substantial number of people, or create a demand for housing. The proposed project could lead to additional recreational users and visitors to the Reserve, but not in excessive amounts that cannot be accommodated. Thus, impacts associated with these checklist topics would be less than significant and will not be analyzed further in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 14 **PUBLIC SERVICES –** | | | | |
| Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services: | | | | |
| a) Fire protection? | ☐ | ☐ | ■ | ☐ |
| b) Police protection? | ☐ | ☐ | ■ | ☐ |
| c) Schools? | ☐ | ☐ | ☐ | ■ |
| d) Parks? | ☐ | ☐ | ☐ | ■ |
| e) Other public facilities? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP or Program EIR significance standards.

**Discussion of Checklist Questions:**

14a) Proposed management activities would not require the construction or alteration of new public service facilities in order to maintain acceptable response times or service ratios. Roads to the Reserve would remain the same, and therefore access by fire or police protection personnel along these roads would remain unchanged from current conditions. Forest thinning, removal of understory vegetation, and new and improved trails may enhance visibility and access for emergency personnel who may need to enter the Reserve in response to an emergency.

There would be no impacts to school facilities or other parks. Over time, the proposed project would enhance the Reserve as a publicly-accessible open space for those seeking both active and passive recreation.

The proposed project would not have a substantial adverse effect with regard to these checklist topics, which need not be analyzed further in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 15. **RECREATION –** | | | | |
| a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated? | ☐ | ☐ | ☐ | ■ |
| b) Does the project include recreational facilities or require the construction or expansion of recreational facilities, which might have an adverse physical effect on the environment? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. There are no additionally applicable LRDP or Program EIR significance standards.

**Discussion of Checklist Questions:**

15a) & b) The proposed project seeks to improve the Reserve as an open space resource for UCSF and for the community at large. Increased use of the Reserve may occur, but not at levels that cannot be accommodated or that would cause substantial physical deterioration of the Reserve. Proposed management activities would not increase the use of existing neighborhood and regional parks or other recreational facilities, or contribute to their deterioration. It would not require the construction or expansion of recreational facilities.

The proposed project would not have a substantial adverse effect on recreational resources. Therefore, no further study of recreation in the EIR is necessary.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 16. **TRANSPORTATION/TRAFFIC –** Would the project**:** | | | | |
| a) Conflict with an applicable plan, ordinance, or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit? | ☐ | ☐ | ■ | ☐ |
| b) Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways? | ☐ | ☐ | ■ | ☐ |
| c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks? | ☐ | ☐ | ☐ | ■ |
| d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)? | ☐ | ☐ | ☐ | ■ |
| e) Result in inadequate emergency access? | ☐ | ☐ | ■ | ☐ |
| f) Result in inadequate parking capacity? | ☐ | ☐ | ■ | ☐ |
| g) Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities? | ☐ | ☐ | ☐ | ■ |
| h) Exceed the applicable LRDP EIR standard of significance by causing substantial conflict among autos, bicyclists, pedestrians, and transit vehicles? | ☐ | ☐ | ■ | ☐ |

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| i) Exceed the applicable LRDP EIR standard of significance by generating transit demand that transit systems or projected transit service would not be able to accommodate? | ☐ | ☐ | ■ | ☐ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic. In addition, the capacity of local area transit services is identified as a standard of significance.

Regarding traffic increases discussed under impact question a), a substantial increase in traffic is one that would cause the corridor or intersection level of service to drop during the peak hour below acceptable levels of service based on local traffic standards, or would cause a corridor or intersection already operating at an unacceptable level of service to further deteriorate during the peak hour to an extent determined to be significant by local traffic standards.

**Discussion of Checklist Questions:**

16a) – i) Proposed management activities would not: conflict with an applicable plan, ordinance or policy regarding the performance of the circulation system; conflict with an applicable congestion management program; result in a change in air traffic patterns; substantially increase hazards due to a roadway design feature; result in inadequate emergency access; result in inadequate parking capacity; conflict with applicable policies, plans or programs supporting alternative transportation; cause a substantial conflict among autos, bicyclists, pedestrians and transit vehicles; or generate transit demand that cannot be accommodated by transit systems.

The proposed project would result in a minor temporary increase in traffic due to the presence of trucks and/or other heavy equipment vehicles for tree thinning and understory removal, but not at levels that would alter the level of service at nearby intersections. Little new truck traffic is expected, as many of the large felled tree trunks would be left on-site, and much of the vegetation would be mulched and left as ground cover. Approximately 2 heavy equipment vehicles would be expected at the site per day during the peak of tree thinning and understory removal activities. In addition, should material be off-hauled, which is not currently anticipated, amounts would be limited, likely resulting in about 2 trucks per day at the site. Access by these vehicles to the Reserve would be from Medical Center Way at Parnassus Avenue, and/or Johnstone Drive at Clarendon Avenue. Worker parking would be accommodated on-campus, at either the Aldea or Surge/Woods parking lots.

At present, conflicts sometimes occur on narrow trails between pedestrians, bike users, and dog owners. UCSF plans to address the issue of trail user conflicts by posting rules and user etiquette. These current conflicts, as well as potential future conflicts associated with new trails, would not rise to a level of significance under CEQA.

The effects of the proposed project on transportation and traffic would be less than significant and need not be evaluated in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 17. **UTILITIES AND SERVICE SYSTEMS –** Would the project: | | | | |
| a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board? | ☐ | ☐ | ☐ | ■ |
| b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects? | ☐ | ☐ | ☐ | ■ |
| c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects? | ☐ | ☐ | ☐ | ■ |
| d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed? | ☐ | ☐ | ☐ | ■ |
| e) Result in a determination by the wastewater treatment provider, which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments? | ☐ | ☐ | ☐ | ■ |
| f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs? | ☐ | ☐ | ■ | ☐ |
| g) Comply with applicable federal, state, and local statutes and regulations related to solid waste? | ☐ | ☐ | ■ | ☐ |
| h) Result in the wasteful, inefficient and unnecessary consumption of energy (see CEQA Statutes Section 21100(b)(3))? | ☐ | ☐ | ■ | ☐ |
| i) Exceed the applicable LRDP EIR standard of significance by requiring or resulting in the construction of new electrical or natural gas facilities, which would cause significant environmental effects? | ☐ | ☐ | ☐ | ■ |

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| j) Exceed the applicable LRDP EIR standard of significance by requiring or resulting in the construction of new chilled water or steam generation facilities, the construction of which would cause significant environmental effects? | ☐ | ☐ | ☐ | ■ |

**Standards of Significance**

The impact questions above constitute the significance standards for this environmental topic.

**Discussion of Checklist Questions:**

17a) – e) As discussed under topic #8 Hydrology and Water Quality, proposed management activities would not alter hydrology or water quality at the site. The project does not propose to pave or modify the imperviousness of surface soils, thus drainage patterns of the site and the amount of surface runoff would not change with the proposed project. As such, the project would not cause an exceedance of wastewater treatment requirements, require the construction of water or wastewater treatment facilities, require new or stormwater drainage facilities. While some irrigation of new plantings may be necessary until new plants are established, sufficient water supplies exist to accommodate these needs.

17f) – j) Large felled tree trunks would be left on site, and understory vegetation would be mulched and left on site as ground cover. There would be little if any material that would be taken to landfill.

The project would not result in the wasteful consumption of energy, or require the construction of new electrical or natural gas facilities or new chilled water or steam generation facilities.

Impacts of the proposed project with regard to utilities, service systems, and energy would be less than significant. These checklist topics will not be analyzed further in the EIR.

| Issues | Potentially Significant Impact | Less than Significant with Project Mitigation | Less Than Significant Impact | No Impact |
|---|---|---|---|---|
| 18. **MANDATORY FINDINGS OF SIGNIFICANCE –** The lead agency shall find that a project may have a significant effect on the environment and thereby require an EIR to be prepared for the project where there is substantial evidence, in light of the whole record, that any of the following conditions may occur. Where prior to commencement of the environmental analysis a project proponent agrees to mitigation measures or project modifications that would avoid any significant effect on the environment or would mitigate the significant environmental effect, a lead agency need not prepare an EIR solely because without mitigation the environmental effects would have been significant (per Section 15065 of the *State CEQA Guidelines*): | | | | |
| a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory? | ■ | ☐ | ☐ | ☐ |
| b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of past, present and probable future projects)? | ■ | ☐ | ☐ | ☐ |
| c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly? | ■ | ☐ | ☐ | ☐ |

## VI. SUPPORTING INFORMATION SOURCES

Final Environmental Impact Report on the 1996 UCSF Long Range Development Plan (1996 LRDP and LRDP FEIR), certified by The Regents January 17, 1997 (State Clearinghouse No. 1995123032)

Final Environmental Impact Report on the UCSF Long Range Development Plan Amendment #2, Hospital Replacement EIR, certified by The Regents March 17, 2005 (State Clearinghouse No. 2004072067)

Mount Sutro Open Space Reserve Management Plan (UCSF, 2001)

Association of Bay Area Governments, Tsunami Inundation Map for Coastal Evacuation. Available at: http://quake.abag.ca.gov/tsunamis/ (ABAG 2009)

Bay Area Area Quality Management District, Regulation 7: Odorous Substances, Amended 1982. Available at: http://www.baaqmd.gov/Divisions/Planning-and-Research/Rules-and-Regulations.aspx

California Department of Conservation, California Geological Survey, State of California Seismic Hazard Zones, City and County of San Francisco, 2000. Available at: http://gmw.consrv.ca.gov/shmp/download/pdf/ozn_sf.pdf. (CGS 2000)

## Wong, Diane C.

**From:** Rk Bose <fk94131@yahoo.com>
**Sent:** Monday, January 17, 2011 12:32 PM
**To:** Campus Planning - EIR
**Cc:** French, Barbara
**Subject:** Comments on "Initial Study"

Dear Diane,

Here are my comments on the Initial Study. (See below.)

Thanks,

Rupa Bose

COMMENTS on Initial Study

p17:

1. Light and Glare. The impact of building the new trail up from Clarendon Avenue could expose parts of the Forest Knolls neighborhood to significantly increased light and glare from the Aldea Campus as the screen effect of the trees and the understory is decreased.

While CEQA may not require impacts on private residences to be evaluated, given that this project area is surrounded by residential neighborhoods, UCSF's deliberate ignoring of these impacts in the EIR appears callous.

2. Wind effects. It is disingenuous to conclude that wind effects will be less that significant. The proposal calls for removing over 90% of the forest's trees and most of the understory. The remaining trees, spaced 30 feet or more apart, with a thinned understory, cannot act as a windbreak. A distance of 30 feet is approximately the width of a street. Changes in wind patterns are inevitable, and cannot be revealed by the demonstration projects. Not only will this affect surrounding areas as well as the forest itself, it is likely to lead to further tree failures.

p 28:

3. Unstable soil. The experience of nearby Twin Peaks clearly indicates that the soil on these steep slopes can become unstable. Destroying trees, and the resulting gradual decay of their root systems, could seriously impact soil stability resulting in soil movement and potential mudslides and landslides, including destabilizing the slopes in neighboring areas below the mountain.

p 32:

4. Herbicides. Though the Initial study mentions "herbicides" it does not specify which ones. Different herbicides have considerable differences in toxicity, biological impacts, and persistence. It is discouraging the UCSF November report conflates Roundup and Garlon. "UCSF is evaluating Roundup as a result of recent studies on the active ingredient in Roundup and similar glyphosate-based herbicides such as Garlon…" (November report, p.8)

First, the re-evaluation related to the so-called “inactive” ingredient of Roundup, not glyphosate (though that too, deserves evaluation). Second, Garlon is not a glyphosate-based herbicide. Its active ingredient is the far more toxic chemical, triclopyr.

p 33:

5. Hydrology. The removal of 90% of the trees, and most of the understory of the forest will inevitably have a major impact on the way water runs off the mountain. Declaring this effect to be “insignificant” is clearly a mistake.

p 38:

6. Noise. The report minimizes the impact of tree and undergrowth removal on noise. By providing soft, sound-absorbing surfaces, the dense vegetation of the forest has a noise-damping effect in the whole surrounding area. Thinning this vegetation by removing thousands of trees and most of the vines and understory would have a significant impact and should be considered in the EIR.

www.savesutro.com

## Wong, Diane C.

**From:** Morley <mzinger1@comcast.net>
**Sent:** Monday, January 17, 2011 6:37 PM
**To:** Campus Planning - EIR
**Cc:** Fionamacpa@gmail.com; erin.keenan@sen.ca.gov
**Subject:** comment on intitial study for UCSF EIR

Consistent with past action and performance, the info presented to date on the EIR is disingenuous, a transparent attempt to fulfill the legal requirements and bypass many important issues.

At the recent meeting on Jan 10th, supposedly to listen to the community, a slide was put up very briefly, where it was not possible to discern which items would be addressed in the EIR and which would be regarded as not relevant.
The meeting, where no valid exchange of information was allowed, seemed to serve no purpose other than to construct an appearance of community participation.

To ignore the potential effects on light, on soil stability, on water runoff, on noise, on wind patterns and microclimates, and the effects of herbicides is insulting to the intelligence of the surrounding neighborhoods, who have clearly expressed their opposition.
It serves, by deception, to further the clearly defined agenda of UCSF to ultimately destroy the existing forest and to promote native planting.

And once again, I request from you a statement of the cost of the EIR, who will be performing it, and the source of the funding.

Morley M. Singer M.D.
Professor Emeritus
177 Belgrave Ave.
San Francisco, Ca.

TO: Diane Wong, UCSF Campus Planning DATE: 1-18-2011
PHEIR@PLANNING.UCSF.EDU VIA: email
RE: Feedback RE: Initial Study for Environmental Impact Report (EIR) for **Sutro Forest**

UCSF proposes to carry out four (4) Demonstration Projects in Mount Sutro Forest to establish a long range management plan for the forest. The plan indicates that if the Demonstration Projects are deemed successful by UCSF the management plan will be extended to remaining areas of the Open Space Reserve.
Expected scenario:
Initial tree removal will establish typical tree spacing at thirty feet (30') between trees, widened to sixty feet (60') at Demonstration Project 4. Trees are to be sawn off close to grade, with stumps either tarped over, hand pruned or treated with herbicides to ensure that there will be no re-growth of removed trees. Undergrowth will be mowed 90-100%, with some spot use of herbicides on tree vine and blackberry stems. Planting of 'native' trees is indicated only for Demonstration Project 4.
Comments by UCSF faculty and staff involved in the planning for Mount Sutro Open Space Reserve indicate they expect the EIR to indicate success of the Demonstration Projects. If so we can expect the following:

- As trees are removed the remaining stumps and root systems will be treated in such manners to prevent resprouting.
- Over time the remaining trees (generally Eucalyptus) will die (age/wind/health/etc.) and the remaining stumps will also be treated to prevent resprouting.
- Over time almost all trees (Eucalyptus) will be gone from the Reserve.
- Some 'native' trees will be planted, as they were at the Rotary Clearing where three (3) oak trees are now growing.

| | |
|---|---|
| **61 ACRES**: | size of Mount Sutro Open Space Reserve. |
| **740 TREES PER ACRE**: | existing tree density as reported in 'Mount Sutro Open Space Reserve Maintenance and Restoration Plan', July 1999 UCSF Project No. M5351 * |
| **45,000 TREES**: | number of existing trees across entire Reserve. |
| **48 TREES PER ACRE**: | tree density at thirty foot (30') spacing. |
| **2,900 TREES**: | number of trees remaining at completion of initial stage after Demonstration Projects are declared successful by UCSF. |
| **93%**: | percent of trees to be removed across Reserve. |
| **7%**: | percent of existing trees to remain after initial stages. |
| **0**: | ultimate number of Eucalyptus trees in the Reserve. |
| **$13,312,600.00** | estimated cost of changing character of Reserve from forest to open scrub grassland and restoration with native shrub and tree species. (See above *.) |
| **$119,000.00** | estimated subsequent yearly cost for above. (See above *.) |
| **$84,800.00** | estimated cost of a program of conservation of existing native plant resource and maintenance of eucalyptus. (See above *.) |
| **$87,600.00** | estimated subsequent yearly cost for above. (See above *.) |

**The EIR study which UCSF itself proposes to prepare must consider the ultimate result of the proposed Demonstration Projects and Maintenance programs. If the ultimate effects and costs are not considered the EIR is a phony document.**

Sincerely,
Paul Rotter
190 Belgrave Ave. SF,CA 94117
paul@belgravehouse.com

**Public Comment**
**Initial Study of Mount Sutro Management Plan**

Thank you for this opportunity to comment on the Initial Study (IS) of the Mount Sutro Management Plan. The following are the environmental issues that are not adequately addressed by the IS. These issues should be acknowledged, analyzed, and mitigated by the Environmental Impact Review (EIR) of the proposed Management Plan.

**1.e Impact of wind**

This environmental issue should be classified as a "Potentially Significant Impact" because the Management Plan proposes to eradicate over 95% of the trees on Mount Sutro, from 740 trees per acre to a maximum of 30 trees per acre and less in some areas. This constitutes a virtual elimination of the existing forest, not accurately described as "thinning."

The trees that remain will be subjected to a great deal more wind than they are presently. Trees develop their defenses against the wind in a specific location with a specific amount of wind. They develop root systems, angles of repose, and bark thicknesses that are appropriate to the amount of wind to which they are exposed as they grow. If they are suddenly subjected to more wind than they have developed the defenses against, they are likely to fail. At the moment, the IS does not propose to consider the potential failure of remaining trees. Trees not presently identified as hazardous will become so when they are subjected to wind they are unprepared to stand against.

Since wind is accelerated as it travels uphill and Mount Sutro is a steep hill, it is naturally a windy place. Therefore, it is essential that the EIR evaluate the impact of the elimination of most of the windbreak on Mount Sutro.

The Management Plan that was published in 2001, proposed to plant a windbreak of Monterey cypress on the western side of Mount Sutro early in the implementation of the plans to destroy most eucalypts on Mount Sutro. Thus, it acknowledged the need for a windbreak. In contrast, the IS not only refuses to acknowledge the need for a windbreak, it even makes the absurd claim that destroying over 95% of the trees will allow the wind to move freely through the forest, actually strengthening the windbreak ("Thus, a permeable stand of trees may be more effective in functioning as a wind break than a dense stand of trees." Page 18) Who ever wrote that sentence is apparently unfamiliar with the concept of a windbreak, which is, by definition, a barrier to the wind.

**7.b. Greenhouse Gas Emissions**

Destroying thousands of trees will release many tons of carbon into the air in violation of California Law (AB32) which obligates public and private entities to reduce greenhouse gas emissions (of which carbon is a major component) over time. Therefore, the EIR for this project must quantify the release of the tons of carbon resulting from the destruction of thousands of trees and mitigate for that impact.

**8.a. Hazardous Materials/Herbicides**

The EIR must identify which herbicide UCSF intends to use in order to evaluate its potential impacts. All herbicides are not created equal. Some are substantially more toxic than others. Some are more harmful to specific species of animal. Some are selective, others are not, etc., etc. This is not an issue to be considered in

the abstract unless UCSF is prepared to choose between using herbicides or not. Since UCSF states their intention to use herbicides, they must identify which herbicide they intend to use.

Bait and switch will not be a viable strategy for UCSF, given that its neighbors are concerned about herbicide use and are watching this project closely. It would not be credible, for example, for the EIR to claim that UCSF plans to use Roundup to kill the roots of non-native trees, because Roundup is well known to be ineffective for that purpose. The considerably more toxic Garlon is now being used by all managers of public lands for this purpose. In fact, the Natural Areas Program, managing the Interior Greenbelt neighboring Mount Sutro, uses Garlon almost exclusively. About 75% of all their herbicide applications are spraying a wide range of plants considered "invasive" with Garlon. Claims that this toxic herbicide will only be "dabbed or injected" are also not credible because it is well known that spraying is the usual method of application. Subsequent claims that "Adaptive Management" required a change to a more toxic chemical after the EIR is complete will not be credible because the use of Garlon is well established as the herbicide of choice for native plant restorations.

**8.h. Wildfires**

The EIR must answer the questions posed by FEMA in their letter to UCSF of October 1, 2009, regarding the potential for UCSF's project to increase fire hazard on Mount Sutro:

> *"Commenters argue that **the proposed projects would increase wildfire hazard by removing some of the material that collects fog drip and keeps the forest moist and resistant to ignition and fire, thus allowing the forest to dry out more easily and increase the relative hazard for ignition.** Can UCSF specifically address this comment and describe how overall forest moisture content will change after implementation of the proposed projects? Please provide scientific evidence to support any claims."*
>
> *"Additionally, several of these unsolicited public comments have stated that the proposed projects could result in changed wind patterns on Mount Sutro which could also increase the wildfire hazard in the forest. New wind patterns could reduce biomass moisture as well as reduce the effective windbreak created by the current forest. These comments argue that **the effective windbreak created by the existing forest limits the potential for wildfire spread in the forest and the immediately surrounding area.** As UCSF has stated, winds are a contributing factor in wildfires. Provide a citable and logical defense regarding how the proposed projects, and the resulting changes in wind patterns, would not result in an increase in the wildfire hazard in the Sutro Forest."*

UCSF chose to withdraw its FEMA application to fund its project, rather than to respond to these questions. However, these questions remain and have yet to be answered. FEMA and its scientific staff considered these legitimate questions and they are demanding answers to these questions in order to fund similar projects in the East Bay. Therefore, an EIR for the project on Mount Sutro that does not answer these questions would not be adequate.

**9.c.d.e Drainage, Runoff**

These issues should be classified as "Potentially Significant Impact" because of the destruction of 90-100% of the understory and the forest. In attempting to dismiss drainage issues, the IS erroneously states, "trees to be removed would be cut above ground surface and root systems would be left in place." (page 34) This is a fundamental misunderstanding of the function of root systems. They are the source of water and nutrients to the plant above ground. When that plant dies or is killed, the roots decay and are no longer functional. When those roots decay, the water that they had previously absorbed runs off the land until it reaches its lowest point, in this case the bottom of a steep hill. The course of that water cannot be predicted with accuracy

without a great deal of study of the lay of the land. The EIR must acknowledge, analyze, and mitigate for significant changes in drainage and runoff.

**10.a-d. Land Use Planning**

The IS states, "The UCSF Mount Sutro Management Plan is the guiding document which forms the basis of proposed management activities." In that case, the EIR should explain why plans to plant a windbreak of Monterey cypress on the western side of Mount Sutro have been abandoned by the proposed project.

**17.d. Water Supplies**

The IS does not acknowledge the plans to irrigate the native plant restorations that will replace the eradicated non-native plants and trees. The native plant restoration on the summit of Mount Sutro has an extensive irrigation system that was used for about 5 years. The EIR must quantify the amount of additional water required to establish the new, extensive native plant garden and confirm that those additional supplies are indeed available to UCSF.

**18.b. Cumulative Impacts**

The project on Mount Sutro is one of many similar projects in the San Francisco Bay Area. Virtually every manager of public lands is eradicating non-native trees. In San Francisco alone, the Natural Areas Program has destroyed thousands of non-native trees and intends to destroy thousands more. Its management plan identified 18,500 trees over 15 feet tall for removal. In addition to those large trees, countless smaller trees will be destroyed that are not quantified by the plan. This massive tree destruction has cumulative impacts which CEQA requires be identified. FEMA is presently conducting an EIS for similar projects in the East Bay. They have made a commitment to take into consideration all similar projects in the Bay Area in order to evaluate the cumulative impact on the environment. UCSF is legally obligated to do the same.

**In conclusion**

Thank you for your consideration of these comments. I look forward to an EIR that will address these issues. The reputation of the University of California is at stake. An institution that is dedicated to science cannot afford to make counterfactual statements such as claiming that a windbreak is strengthened by destroying 95% of the trees or that root systems live on in perpetuity after plants and trees are destroyed.

Mary McAllister
January 17, 2011

## Wong, Diane C.

**From:** alicia snow <alicia_snow@sbcglobal.net>
**Sent:** Tuesday, January 18, 2011 3:30 PM
**To:** Campus Planning - EIR
**Cc:** Erin.keenan@sen.ca.gov; Morley Singer; Rupa Bose; Mary McAllister
**Subject:** Neighborhood Feedback on EIR for Sutro Forest

Ms. Diane Wong:

As a UCSF neighbor of over thirty years, I should like to go on record in rejection of the proposed management of the Sutro Forest.

This proposal is nothing short of the devastation of an existing ecosystem which has flourished for 120 years. According to your own initial proposal, it will cost the University (which is, let us not forget, a taxpayer funded institution) an estimated $13 million to achieve, and an estimated $87,600 to maintain, for every year thereafter.

Your cavalier acceptance of such a high cost in the face of university budget cuts, California State budget cuts, and city of San Francsico budget cuts, is appalling as it is.

Add to this, the shameless decision to use herbicides known to have been banned in the European Union, where there is a more rigorous testing procedure than in our own country due to corruption in the Environmental Protection Agency, and your proposal begins to look criminal for the potential harm it can cause our environment.

You represent a Medical Institution. The first maxim of medicine is "First, do no harm."

You operate in a city where the Department of the Environment claims to follow the Precautionary Principle. But you choose to sidestep inconvenient facts to further the Nativist agenda. In so doing, you choose to put countless beneficial insects, beneficial plants, native and non-native creatures, and your own neighborhood at risk of groundwater pollutants - and you exacerbate this situation by felling 93% of the trees which would have been able to sequester carbon dioxide from the air.

Birds and Fish are dying by the millions. Colony Collapse Disorder is decimating the honeybee population. Frogs are suffering severe endocrine disruption, and there are studies pointing to more and more trouble in the human populations that must live near herbicide and pesticide use.

How do you propose to square this with your conscience when the results of true scientists, accumulate?

Alicia Snow
1586 Shraser Street
San Francisco, CA 94117

## Wong, Diane C.

**From:** Patricia Greene <greene@cgl.ucsf.edu>
**Sent:** Wednesday, January 12, 2011 3:12 PM
**To:** Campus Planning - EIR
**Subject:** Mt Sutro EIR scoping meeting

Dear Ms. Wong,

I attended the Jan 10, 2011 scoping meeting at Millberry Union. Since this was the first evening meeting on management of the Sutro Forest that I have attended, I did not feel prepared to speak.

There were some aspects of the plans that I would have expected in a presentation on the EIR, but I did not hear much about--maybe they have been discussed in detail previously:

1. What about the effect of the project on the wildlife that is currently adapted to living in the forest?
2. Will the current microclimate of Mt Sutro (as compared to Twin Peaks) be given consideration?

1. I don't know about all of the Mt Sutro wildlife--my personal experience is that I carry binoculars to look at birds, and I listen when I walk there. I bird in many sites within San Francisco and around the Bay Area, and nowhere else have I heard and seen a Winter Wren population like that on Mt Sutro. I have seen (or heard) one or two in Golden Gate Park, in the Presidio or on Mt Davidson; none of these sites compares with Sutro Forest. Right now even in January, you can hear Winter Wrens scold as you hike the trails, and soon, the forest will be alive with the amazingly long intricate rapid songs of these tiny birds. There are many places along the trails where defense of at least three independent territories can be heard (multiply this by more than one trail). Swainson's Thrushes were also heard last spring and into the summer; I believe that the only other place in SF where these are generally heard is Lobos Creek. Many of the other birds I see on Mt Sutro are common in other birding sites in SF, but the Winter Wren population seems very special. Wholesale clearing of forest and its understory, will decimate these birds' habitat. I understand that some clearing may be necessary and desirable, but I truly hope that some consideration will be given to these birds (and other wildlife) that has adapted to the current Forest.

2. Hiking the slopes and the summit of Mt Sutro or Twin peaks offers two vastly different experiences. Even on a windy day, Mt Sutro is mild, and the trails are pleasant to walk, while the wind on Twin Peaks is raging beyond adventure. Since these two summits are so close together and part of the same ridge, I would guess that before the Sutro Forest grew up, the micro-climates of both summits was like that of Twin Peaks today. The mature forest that currently covers the top of Mt Sutro provides those of us who live and walk here with a pocket of more moderate microclimate that I, for one, treasure. I hope that serious consideration of the climatic effect on this corner of SF will be considered in the management of the forest and that the moderating effects of the forest will be preserved.

There are other wondrous aspects of the forest that I fear will be lost. Have you walked there in February when the plums (non-native, I believe) are blooming? I hope, at least some areas of plums will be left "non-native".

Monday, was my first evening meeting on the subject of Mt Sutro Forest Management, but I did go on an earlier walk that was led by a forest management professional. It centered around the Woods parking lot and that area of the forest. I took away a couple of things from what I heard the forester say. (1) Most important was that the worst thing that could be done to a mature Eucalyptus forest would be to cut it down and not prevent regrowth of smaller feeder trees from each stump-- apparently this very situation contributed to the ferocity of the East Bay hills fire. (2) Some of the worst fire hazard in that immediate area was the tinder dry wooden fences in the backyards of the Edgewood neighbors that abut

the parking lot. (3) While the unmanaged forest does represent some fire hazard, in this particular location (western, foggy SF), there are very few days in a year when it is dry enough to constitute "fire" weather.

At Monday's meeting, I heard that "adaptive management" would be used to help decide how to proceed after the demonstration projects. When I heard that phrase, I thought that there would be discussion about retaining (or at a minimum evaluating) habitat for resident birds and other wildlife and also evaluating retention of some of the other beneficial aspects of the current forest. But in Monday's presentation, "adaptive management" seemed to refer primarily to evaluating whether extending clearing beyond the demonstration areas would rely on herbicides or on other methods of preventing regrowth of Eucalyptus and understory. I hope that the clearing of mature trees will not outstrip the ability (and the budget) to manage regrowth-- especially if the only method that can be extended is through the use of herbicides. Adhering to the letter of SF law doesn't really seem like an adequate standard for a campus that purports to advance good health. And I hope that "adaptive management" in the the whole plan, as opposed to the brief Jan 10 meeting, is concerned with preserving some of the positive aspects of the current Mt Sutro Forest.

Yours,
Pat Greene

**********

Patricia Greene
145 Woodland Avenue
San Francisco, CA
415 566 6637
greene@cgl.ucsf.edu

# APPENDIX B

AIR EMISSIONS ESTIMATES

**10/14/2012 5:17:57 PM**

Urbemis 2007 Version 9.2.4

Combined Summer Emissions Reports (Pounds/Day)

File Name: C:\Users\pfranke\AppData\Roaming\Urbemis\Version9a\Projects\Mount Sutro.urb924

Project Name: UCSF Mount Sutro

Project Location: Bay Area Air District

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

**10/14/2012 5:17:57 PM**

Summary Report: Summer 2013 (Pounds/Day)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 TOTALS (lbs/day unmitigated) | 2.58 | 20.61 | 12.01 | 0.00 | 75.00 | 0.99 | 75.99 | 15.66 | 0.91 | 16.57 | 2,349.41 |
| 2013 TOTALS (lbs/day mitigated) | 2.58 | 20.61 | 12.01 | 0.00 | 10.08 | 0.15 | 10.23 | 2.11 | 0.14 | 2.24 | 2,349.41 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.02 | 1.55 | 0.00 | 0.01 | 0.01 | 2.81 |
| TOTALS (lbs/day, mitigated) | 0.12 | 0.02 | 1.55 | 0.00 | 0.01 | 0.01 | 2.81 |
| Percent Reduction | 0.00 | 0.00 | 0.00 | NaN | 0.00 | 0.00 | 0.00 |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.23 | 0.11 | 1.13 | 0.00 | 0.23 | 0.04 | 131.68 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.35 | 0.13 | 2.68 | 0.00 | 0.24 | 0.05 | 134.49 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:24:55 PM**

Summary Report: Winter 2013 (Pounds/Day)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 TOTALS (lbs/day unmitigated) | 2.58 | 20.61 | 12.01 | 0.00 | 75.00 | 0.99 | 75.99 | 15.66 | 0.91 | 16.57 | 2,349.41 |
| 2013 TOTALS (lbs/day mitigated) | 2.58 | 20.61 | 12.01 | 0.00 | 10.08 | 0.15 | 10.23 | 2.11 | 0.14 | 2.24 | 2,349.41 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.00 | | | | | | |
| TOTALS (lbs/day, mitigated) | 0.00 | | | | | | |
| Percent Reduction | NaN | NaN | NaN | NaN | NaN | NaN | NaN |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 | 113.67 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 | 113.67 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:25:52 PM**

Summary Report: Combined Annual Emissions 2013 (Tons/Year)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 TOTALS (tons/year unmitigated) | 0.07 | 0.55 | 0.32 | 0.00 | 1.99 | 0.03 | 2.01 | 0.42 | 0.02 | 0.44 | 62.26 |
| 2013 TOTALS (tons/year mitigated) | 0.07 | 0.55 | 0.32 | 0.00 | 0.27 | 0.00 | 0.27 | 0.06 | 0.00 | 0.06 | 62.26 |
| Percent Reduction | 0.00 | 0.00 | 0.00 | 0.00 | 86.56 | 84.78 | 86.54 | 86.55 | 84.80 | 86.46 | 0.00 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.01 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.25 |
| TOTALS (tons/year, mitigated) | 0.01 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.25 |
| Percent Reduction | 0.00 | NaN | 0.00 | NaN | NaN | NaN | 0.00 |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.03 | 0.02 | 0.21 | 0.00 | 0.04 | 0.01 | 22.94 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.04 | 0.02 | 0.35 | 0.00 | 0.04 | 0.01 | 23.19 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:42:28 PM**

## Summary Report: Summer 2014 (Pounds/Day)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 TOTALS (lbs/day unmitigated) | 2.44 | 19.12 | 11.57 | 0.00 | 75.00 | 0.89 | 75.89 | 15.66 | 0.82 | 16.48 | 2,349.46 |
| 2014 TOTALS (lbs/day mitigated) | 2.44 | 19.12 | 11.57 | 0.00 | 10.08 | 0.14 | 10.22 | 2.11 | 0.12 | 2.23 | 2,349.46 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.02 | 1.55 | 0.00 | 0.01 | 0.01 | 2.81 |
| TOTALS (lbs/day, mitigated) | 0.12 | 0.02 | 1.55 | 0.00 | 0.01 | 0.01 | 2.81 |
| Percent Reduction | 0.00 | 0.00 | 0.00 | NaN | 0.00 | 0.00 | 0.00 |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.23 | 0.11 | 1.13 | 0.00 | 0.23 | 0.04 | 131.68 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.35 | 0.13 | 2.68 | 0.00 | 0.24 | 0.05 | 134.49 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:43:14 PM**

Summary Report: Winter 2014 (Pounds/Day)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 TOTALS (lbs/day unmitigated) | 2.44 | 19.12 | 11.57 | 0.00 | 75.00 | 0.89 | 75.89 | 15.66 | 0.82 | 16.48 | 2,349.46 |
| 2014 TOTALS (lbs/day mitigated) | 2.44 | 19.12 | 11.57 | 0.00 | 10.08 | 0.14 | 10.22 | 2.11 | 0.12 | 2.23 | 2,349.46 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.00 | | | | | | |
| TOTALS (lbs/day, mitigated) | 0.00 | | | | | | |
| Percent Reduction | NaN | NaN | NaN | NaN | NaN | NaN | NaN |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 | 113.67 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 | 113.67 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:43:28 PM**

Summary Report: Combined Annual Emissions 2014 (Tons/Year)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 TOTALS (tons/year unmitigated) | 0.06 | 0.51 | 0.31 | 0.00 | 1.99 | 0.02 | 2.01 | 0.42 | 0.02 | 0.44 | 62.26 |
| 2014 TOTALS (tons/year mitigated) | 0.06 | 0.51 | 0.31 | 0.00 | 0.27 | 0.00 | 0.27 | 0.06 | 0.00 | 0.06 | 62.26 |
| Percent Reduction | 0.00 | 0.00 | 0.00 | 0.00 | 86.56 | 84.75 | 86.54 | 86.55 | 84.78 | 86.47 | 0.00 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.01 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.25 |
| TOTALS (tons/year, mitigated) | 0.01 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.25 |
| Percent Reduction | 0.00 | NaN | 0.00 | NaN | NaN | NaN | 0.00 |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.03 | 0.02 | 0.21 | 0.00 | 0.04 | 0.01 | 22.94 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.04 | 0.02 | 0.35 | 0.00 | 0.04 | 0.01 | 23.19 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:45:53 PM**

Summary Report: Summer 2015 (Pounds/Day)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 TOTALS (lbs/day unmitigated) | 2.28 | 17.54 | 11.17 | 0.00 | 75.00 | 0.81 | 75.82 | 15.66 | 0.75 | 16.41 | 2,349.50 |
| 2015 TOTALS (lbs/day mitigated) | 2.28 | 17.54 | 11.17 | 0.00 | 10.08 | 0.12 | 10.21 | 2.11 | 0.11 | 2.22 | 2,349.50 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.02 | 1.55 | 0.00 | 0.01 | 0.01 | 2.81 |
| TOTALS (lbs/day, mitigated) | 0.12 | 0.02 | 1.55 | 0.00 | 0.01 | 0.01 | 2.81 |
| Percent Reduction | 0.00 | 0.00 | 0.00 | NaN | 0.00 | 0.00 | 0.00 |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.23 | 0.11 | 1.13 | 0.00 | 0.23 | 0.04 | 131.68 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.35 | 0.13 | 2.68 | 0.00 | 0.24 | 0.05 | 134.49 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:46:08 PM**

Summary Report: Winter 2015 (Pounds/Day)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 TOTALS (lbs/day unmitigated) | 2.28 | 17.54 | 11.17 | 0.00 | 75.00 | 0.81 | 75.82 | 15.66 | 0.75 | 16.41 | 2,349.50 |
| 2015 TOTALS (lbs/day mitigated) | 2.28 | 17.54 | 11.17 | 0.00 | 10.08 | 0.12 | 10.21 | 2.11 | 0.11 | 2.22 | 2,349.50 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.00 | | | | | | |
| TOTALS (lbs/day, mitigated) | 0.00 | | | | | | |
| Percent Reduction | NaN | NaN | NaN | NaN | NaN | NaN | NaN |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 | 113.67 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (lbs/day, unmitigated) | 0.12 | 0.16 | 1.25 | 0.00 | 0.23 | 0.04 | 113.67 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

**10/14/2012 5:46:19 PM**

Summary Report: Combined Annual Emissions 2015 (Tons/Year)

CONSTRUCTION EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 Dust | PM10 Exhaust | PM10 | PM2.5 Dust | PM2.5 Exhaust | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 TOTALS (tons/year unmitigated) | 0.06 | 0.46 | 0.30 | 0.00 | 1.99 | 0.02 | 2.01 | 0.42 | 0.02 | 0.43 | 62.26 |
| 2015 TOTALS (tons/year mitigated) | 0.06 | 0.46 | 0.30 | 0.00 | 0.27 | 0.00 | 0.27 | 0.06 | 0.00 | 0.06 | 62.26 |
| Percent Reduction | 0.00 | 0.00 | 0.00 | 0.00 | 86.56 | 84.73 | 86.54 | 86.55 | 84.76 | 86.47 | 0.00 |

AREA SOURCE EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.01 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.25 |
| TOTALS (tons/year, mitigated) | 0.01 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.25 |
| Percent Reduction | 0.00 | NaN | 0.00 | NaN | NaN | NaN | 0.00 |

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.03 | 0.02 | 0.21 | 0.00 | 0.04 | 0.01 | 22.94 |

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

| | ROG | NOx | CO | SO2 | PM10 | PM2.5 | CO2 |
|---|---|---|---|---|---|---|---|
| TOTALS (tons/year, unmitigated) | 0.04 | 0.02 | 0.35 | 0.00 | 0.04 | 0.01 | 23.19 |

Both Area and Operational Mitigation must be turned on to get a combined mitigated total.

# APPENDIX C

BIOLOGICAL RESOURCES REPORT

# BIOLOGICAL RESOURCES REPORT

## MOUNT SUTRO OPEN SPACE RESERVE
## SAN FRANCISCO, CALIFORNIA

LSA

April 1, 2011
(Revised September 27, 2011)

# BIOLOGICAL RESOURCES REPORT

## MOUNT SUTRO OPEN SPACE RESERVE

## SAN FRANCISCO, CALIFORNIA

Submitted to:

University of California, San Francisco
654 Minnesota Street
San Francisco, California 94143-0286
(415) 476-8326

Prepared by:

LSA Associates, Inc.
157 Park Place
Point Richmond, California 94801
(510) 236-6810

LSA Project No. USF1001

LSA

April 1, 2011
(Revised September 27, 2011)

# TABLE OF CONTENTS

1.0 INTRODUCTION ..... 1
1.1 PURPOSE ..... 1
1.2 PROJECT LOCATION ..... 1
1.3 PROJECT DESCRIPTION ..... 1
1.4 REGULATORY CONTEXT ..... 8
2.0 METHODS ..... 13
3.0 BIOLOGICAL SETTING ..... 15
3.1 VEGETATION ..... 15
3.2 WILDLIFE ..... 19
3.3 SPECIAL-STATUS SPECIES ..... 21
3.4 SENSITIVE HABITATS ..... 26
4.0 POTENTIAL IMPACTS AND RECOMMENDED MITIGATION MEASURES ..... 28
5.0 REFERENCES ..... 33

## FIGURES

Figure 1: Project Location ..... 2
Figure 2: Demonstration Projects ..... 4
Figure 3: Vegetation Types ..... 16

## TABLES

Table A: Special-status Species Potentially Occurring in the Vicinity of the Mount Sutro Open Space Reserve, San Francisco, California ..... 22

## APPENDICES

A: Plant and Animal Species Lists

# 1.0 INTRODUCTION

## 1.1 PURPOSE

This report presents the results of a biological resources study of the Mount Sutro Open Space Reserve (Reserve) in central San Francisco. The purpose of the study was to identify potentially significant biological resources on the Reserve that may be impacted by the proposed vegetation management program, including tree thinning and native plant habitat enhancement activities, to determine the significance of those impacts, and to propose feasible mitigation measures to avoid or minimize those impacts. The information contained herein is intended to form the basis for the biological resources section of an Environmental Impact Report (EIR) as required by the California Environmental Quality Act (CEQA). For the purposes of this report, "project" collectively refers to the four demonstration projects and ongoing vegetation management activities as described in the Initial Study project description (2010) and Community Planning Process Summary Report (2010), and "project area" refers to the entire Mount Sutro Open Space Reserve (Figure 1).

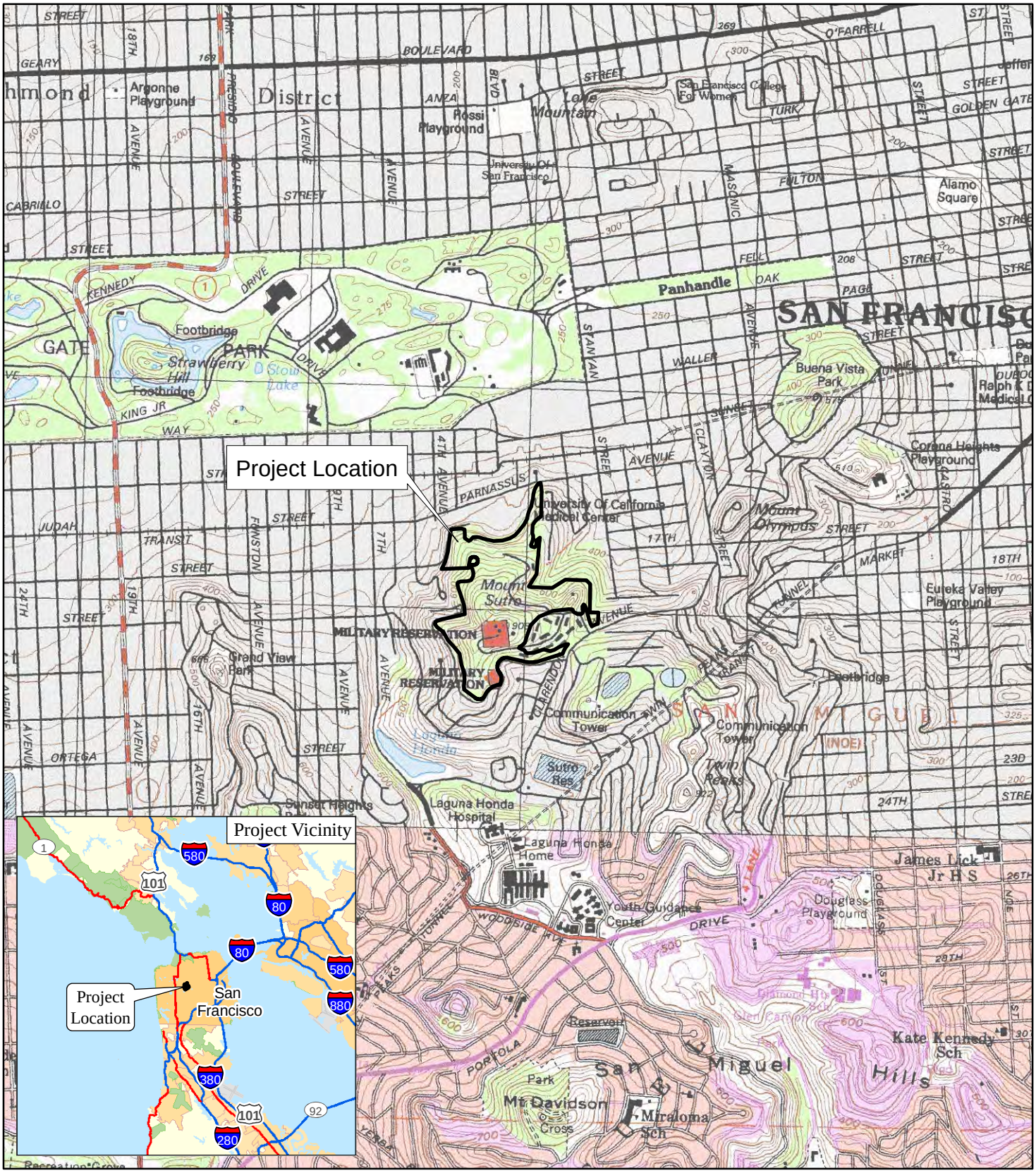
## 1.2 PROJECT LOCATION

The approximately 61-acre Reserve is located on lands owned by the University of California, San Francisco (UCSF) adjacent to and including Mount Sutro, and is generally bordered by the UCSF Parnassus Campus to the north, private residences along Edgewood Avenue and undeveloped City of San Francisco (City) land to the east (i.e., Interior Green Belt Significant Natural Resource Area [SNRA]), Clarendon Avenue and Christopher Drive to the south, and Crestmont Drive and other residential areas to the west (Figure 1). The Reserve vicinity includes the UCSF Medical Center to the north, Cole Valley and the City Interior Greenbelt SNRA to the east, and the Forest Knolls residential neighborhood to the south and west.

## 1.3 PROJECT DESCRIPTION

### 1.3.1 Project Background

In 1997, UCSF revised their Long Range Development Plan (LRDP). During this process, members of the Community Advisory Group (CAG) mentioned that the Reserve eucalyptus forest posed numerous safety risks, while also providing recreational opportunities to the surrounding neighborhoods. The LRDP included recommendations to investigate an appropriate maintenance and restoration program for vegetation and to improve hiking trails on Mount Sutro. The results of this investigation were the Mount Sutro Open Space Reserve Maintenance and Restoration Plan (Hort Science 1999) and the *Mount Sutro Open Space Reserve Management Plan* (EDAW 2001), which identified five conceptual near-term management actions over the next ten years: (1) *Hazardous Tree Removal* near pavement and buildings; (2) *Eucalyptus Thinning* in two demonstration project areas totaling 2.5 acres; (3) *Conversion Planting* to native species in seven demonstration areas totaling 5.3 acres; (4) *Native Plant Enhancement* around three existing native plant communities; and (5) *Trail System Improvements* throughout the Reserve.




LSA

FIGURE 1

N

0 1000 2000
FEET

*Mount Sutro Open Space Reserve, UCSF*

Project Location

SOURCE: USGS Topographical Quads 7.5' and ESRI Streetmap North America

I:\USF1001\GIS\Maps\Figure1_ProjectLocation.mxd (8/23/2011)

The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and other plants and replacement with native species). Vegetation management actions are proposed to occur throughout the Reserve over many years and would be phased beginning with four demonstration projects that were crafted with the interested public in the community process described below. The first three demonstration projects are planned to be implemented in 2011. The fourth demonstration project would be implemented approximately one year after the first three demonstration projects. Also, a "Hands-Off" management area in which no vegetation management would be undertaken for the one-year duration of the demonstration project timeframe, is proposed at the request of some community members. The four demonstration projects are consistent with the following "ten-year management actions" as described on pages 37–49 of the 2001 plan: (1) eucalyptus thinning in Area L; (2) hazardous tree removal in Area I; (3) native plant enhancement in Area E; and (4) conversion planting in Areas N and O. To avoid confusion, these actions will be identified as Demonstration Projects 1 through 4, respectively, for the remainder of this report. Several principles would be employed while implementing management activities, including:

- Adaptive Management: UCSF is committed to the principle of adaptive management as defined in the 2001 plan, allowing for public input and adjustment of management activities before application to other areas of the Reserve.
- Limited Use of Herbicides: Where herbicide use is indicated, targeted spot-application would be employed on tree stumps, vines, blackberry (*Rubus* sp.) and broom (*Genista* sp.) stems, and on poison oak (*Toxicodendron diversilobum*) adjacent to trails.
- Tree Spacing: Where tree removal is indicated, the priority for removal is dead, dying, unhealthy, and hazardous trees. Where trees must be removed to achieve desired spacing, the next priority would be trees smaller than 12 inches in diameter. Healthy trees larger then 12 inches would only be removed to achieve the desired spacing, and are expected to be few in number.

The components of each of the demonstration projects are described below and locations shown on Figure 2.

### 1.3.2 Demonstration Project 1: South Ridge Area (3 acres)

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to an overall average spacing of about 30 feet between trunks
- Tree stump treatment for sprout control: 1 acre – rely on hand maintenance; 1 acre – cover with tarps; 1 acre – apply herbicides
- Sprout control: cut mechanically or use goat grazing 1–2 times per year for 3–5 years in 1 acre where stumps are not tarped or treated with herbicide

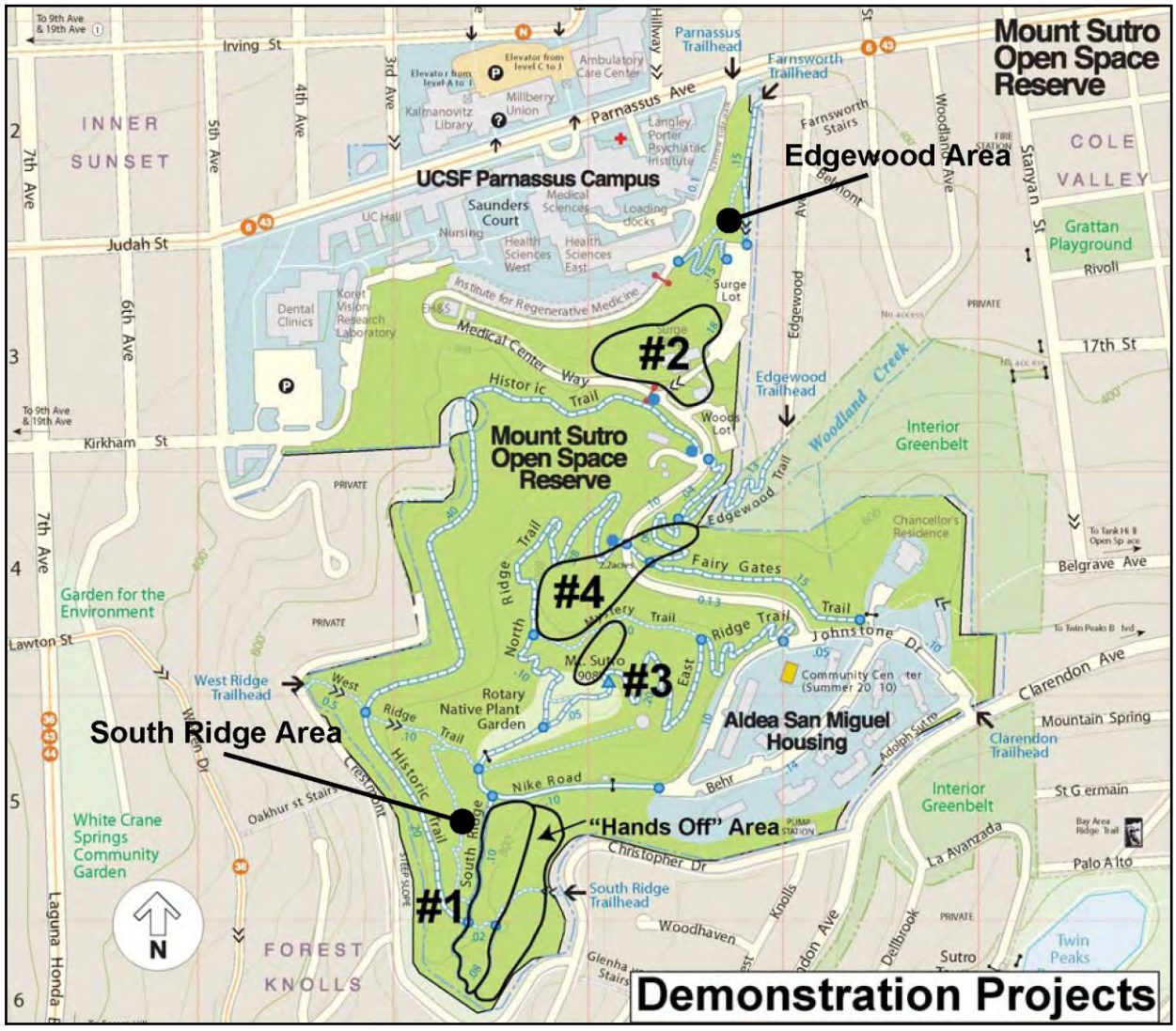



FIGURE 2

*Mount Sutro Open Space Reserve, UCSF*
Demonstration Projects

SOURCE: UCSF

P:\USF1001\g\Figure2_DemonstrationProjects.cdr (1/19/11)

Understory

- Initially, mow up to 90–100 percent (excluding native plants except for poison oak); islands of brush will be maintained for wildlife
- Spot-treat cut tree vines, blackberry stems, and poison oak adjacent to trails with herbicide in 1 acre
- Mow, use goat grazing and/or use herbicides consistent with City standards, annually or every other year for 5 years, depending on rate of re-growth

### 1.3.3 Demonstration Project 2: Edgewood Avenue Area (2 acres)

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning minimal, mostly acacias. Of those areas to be thinned, remaining trees to average spacing of about 30 feet between trunks, close to the spacing that currently exists in most of this area
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Initially, mow up to 90–100 percent (excluding native plants)
- Mow and/or use goat grazing annually or every other year for 5 years, depending on rate of re-growth

### 1.3.4 Demonstration Project 3: North Side of Summit (<0.5 acre)

Trees

- Remove trees minimally, only as needed to prevent shading of existing Nootka reed grass (*Calamagrostis nutkaensis*) stand and to maintain a clear view corridor to the northeast
- Tree stump treatment: cover with tarps
- Sprout control: maintain tarps until stumps are dead

Understory

- Hand-remove non-native plants

### 1.3.5 Demonstration Project 4: East Bowl Corridor (2 acres)

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards

- Removal of dead and unhealthy trees
- Thinning of remaining trees to average spacing of about 60 feet between trunks
- Stump treatment and sprout control would depend on outcome of Demonstration Project 1, but for purposes of this analysis, it is assumed that herbicides would be used (herbicides would not be used if it can be demonstrated in Demonstration Project 1 that stumps can be controlled at a reasonable cost without herbicides)
- Planting of native shrubs and trees (1 acre may be irrigated, 1 acre non-irrigated)

Understory
- Initially, mow up to 90–100 percent (excluding native plants; including poison oak) along trails; large areas of brush will be maintained for wildlife
- Re-growth control depends on the outcome of Demonstration Project 1, but for purposes of this study, it is assumed that herbicides, would be used (herbicides would not be used if it can be demonstrated in Demonstration Project 1 that undesirable understory plants can be controlled at a reasonable cost without herbicides)

### 1.3.6 "Hands Off" Management Area: South Ridge Area (2 Acres)

Trees
- No changes to existing trees, except that maintenance will be performed to remove and prune hazardous trees near homes and trails for the safety of residents and visitors and to keep trails clear (including trash pick-up)

Understory
- No changes except for trash removal along trails

### 1.3.7 Continued Implementation (Entire Reserve)

Edgewood Area
Following the completion and assessment of Demonstration Project 2: Edgewood Avenue Area, management actions proposed in Demonstration Project 2 would be selected for application to the remainder of the Edgewood Avenue Area, including the planting of native trees, shrubs and other plants.

Remainder of the Reserve
Following the completion and assessment of the Demonstration Project 1: South Ridge Area, management actions proposed in Demonstration Project 1 would be selected for application to other areas of the Reserve, excluding the other demonstration project areas, and the Rotary Meadow at the summit. This would include the planting of native species and enhancement of existing remnant native plant communities.

Large-scale tree thinning and understory control would be phased, likely over the course of many years as funding becomes available. It is anticipated that no more than about one-quarter of the Reserve would receive large-scale tree-thinning and understory control treatment at any given time, likely separated by several years before another section of the Reserve is to receive such treatment.

Steep slopes of the Reserve that are inaccessible by heavy equipment (about 15 acres of the 61-acre forest) would not receive tree thinning treatment, though some understory control may be implemented if accessible by foot and if use of hand-tools would be effective.

Following the completion and assessment of Demonstration Project 3: North Side of Summit, management actions proposed in Demonstration Project 3 would be selected for application to other areas of the Reserve, such as select tree removal to create views.

After completion and assessment of Demonstration Project 4: East Bowl Corridor, conversion planting would occur in the Reserve as identified in the 2001 Management Plan: on the summit, in the south Ridge, and in the East Bowl areas (in and around Demonstration Project 4), although not necessarily with all the same species identified in the management plan.

Trails

Over the past several years, trails have been restored and enhanced to improve access throughout the Reserve for the enjoyment of visitors. For example, an historic trail that was only recently discovered was restored by the Mount Sutro Stewards. Three new trails are proposed as part of the project: (1) a trail on the north side of the Reserve connecting the Historic Trail to the campus, allowing for ease of access to/from the campus; (2) a trail connecting the South Ridge Trail to Christopher Drive, allowing for easier public access from the south side of the Reserve; and (3) an extension of this new trail to Clarendon Avenue and to trails to the Interior Greenbelt (on City-owned land) and southeast of the Reserve (see Figure 5). The creation of these new trails will require minimal vegetation removal, minor amounts of grading and new trail markers.

Ongoing Maintenance

The University, with the assistance of the UCSF Mount Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees, and restoring trails. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

### 1.3.7 BMP's to Avoid Indirect Project Impacts on Sensitive Biological Resources

The following best management practices (BMP's) will be incorporated into the project description for treatment of the demonstration areas, continued implementation over the entire reserve, and ongoing maintenance activities.

- Disturbance to existing grades and vegetation will be limited to the actual treatment or restoration area and necessary access routes. Placement of all trails, staging areas, and other facilities will avoid and limit disturbance to existing native plants to the maximum extent practicable, with the exception of poison oak. Where possible, existing ingress or egress points will be used and contours of the work area will be returned to pre-construction condition.
- Disturbed soils resulting from treatment activities will be stabilized prior to the rainy season by spreading wood chips or shreds or other mulch materials over the bare ground.
- Straw wattles, silt fencing, straw bales, or similar sediment control measures will be installed on contour along the lower edge of treatment areas to prevent excess sediment from entering the watershed if it is deemed necessary.

- To avoid attracting predators, food-related trash will be disposed in closed containers and regularly removed from the work area.
- All construction material, wastes, debris, sediment, rubbish, vegetation, trash, fencing, etc. will be removed from the site upon completion of treatments and transported to an authorized disposal area, as appropriate, and per all federal, State, and local laws and regulations.
- All construction-related holes will be covered to prevent entrapment of native amphibians, reptiles, and small mammals.

## 1.4 REGULATORY CONTEXT

Biological resources on the site may fall under the jurisdiction of State and/or federal regulatory agencies and may be subject to various statutes, regulations, and/or codes as described below. In general, the greatest legal protections are provided for species formally listed by the federal or state government. Informally listed species and habitats receive less legal protection.

### 1.4.1 Federal Endangered Species Act

The United States (U.S.) Fish and Wildlife Service (USFWS) has jurisdiction over federally listed threatened and endangered plant and animal species. The federal Endangered Species Act (ESA) protects listed species from harm or "take," broadly defined as to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." Any such activity can be defined as a "take" even if it is unintentional or accidental.

An endangered species is one that is considered in danger of becoming extinct throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered in the foreseeable future. Federal agencies involved in funding or permitting projects that may result in take of federally listed species (e.g., U.S. Army Corps of Engineers) are required under Section 7 of the ESA to consult with the USFWS prior to issuing such permits. Any activity that could result in the take of a federally listed animal species and is not authorized as part of a Section 7 consultation, requires an ESA Section 10 take permit from the USFWS.

In addition to endangered and threatened species, which are legally protected under the ESA, the USFWS maintains lists of proposed and candidate species. Proposed species are those for which a proposed rule to list them as endangered or threatened has been published in the Federal Register. A candidate species is one for which the USFWS currently has enough information to support a proposal to list it as a threatened or endangered species. Proposed species could be listed at any time, and many federal agencies protect them as if they already are listed. Candidate species are not afforded legal protection under the ESA.

### 1.4.2 Clean Water Act

The U.S. Army Corps of Engineers (Corps) is responsible under Section 404 of the Clean Water Act to regulate the discharge of fill material into waters of the U.S. Waters of the U.S. and their lateral limits are defined in 33 Code of Federal Regulations (CFR) Part 328.3(a) and include streams that are tributaries to navigable waters and their adjacent wetlands. The lateral limits of jurisdiction for a non-

tidal stream are measured at the line of the Ordinary High Water Mark (OHWM) (33 CFR Part 328.3[e]) or the limit of adjacent wetlands (33 CFR Part 328.3[b]). Any permanent extension of the limits of an existing water of the U.S., whether natural or man-made, results in a similar extension of Corps jurisdiction (33 CFR Part 328.5).

Waters of the U.S. fall into two broad categories: wetlands and other waters. Other waters include unvegetated waterbodies and watercourses such as rivers, streams, lakes, springs, ponds, coastal waters, and estuaries. Seasonally inundated or intermittent waterbodies or watercourses that do not exhibit wetland characteristics are often classified as other waters of the U.S. Wetlands include marshes, wet meadows, seeps, floodplains, basins, and other areas experiencing extended seasonal or permanent soil saturation that support wetland vegetation. Seasonally or intermittently inundated features, such as seasonal ponds, ephemeral streams, and tidal marshes, are categorized as wetlands if they have hydric soils and support wetland plant communities.

Wetlands and other waters that cannot trace a continuous hydrologic connection to a navigable water of the U.S. are not tributary to waters of the U.S. These are termed "isolated" wetlands and waters. Isolated wetlands and waters are jurisdictional when their destruction or degradation can affect interstate or foreign commerce (33 CFR Part 328.3[a]). The Corps may or may not take jurisdiction over isolated wetlands, depending on the specific circumstances.

In general, a Section 404 permit must be obtained from the Corps before filling or grading jurisdictional wetlands or other waters of the U.S. Certain projects may qualify for authorization under a Nationwide Permit (NWP). The purpose of the NWP program is to streamline the evaluation and approval process throughout the nation for certain types of activities that have only minimal impacts to the aquatic environment. Many NWPs are only authorized after the applicant has submitted a pre-construction notification (PCN) to the appropriate Corps office. The Corps is required to consult with the USFWS and/or the National Marine Fisheries Service (NMFS) under Section 7 of the ESA if the permitted activity may result in the take of federally listed species.

### 1.4.3 Migratory Bird Treaty Act

The federal Migratory Bird Treaty Act (MBTA) prohibits the taking, hunting, killing, selling, purchasing, etc. of migratory birds, parts of migratory birds, or their eggs and nests. As used in the MBTA, the term "take" is defined as "to pursue, hunt, shoot, capture, collect, kill, or attempt to pursue, hunt, shoot, capture, collect, or kill, unless the context otherwise requires." Most bird species native to North America are covered by this act (16 USC 703-712).

### 1.4.4 California Endangered Species Act

The California Department of Fish and Game (CDFG) has jurisdiction over threatened or endangered species that are formally listed by the State under the California ESA. The California ESA is similar to the federal ESA both in process and substance; it is intended to provide additional protection to threatened and endangered species in California. Species may be listed as threatened or endangered under both acts (in which case the provisions of both state and federal laws apply) or under only one act. A candidate species is one that the Fish and Game Commission has formally noticed as being

under review by CDFG for addition to the State list. Candidate species are protected by the provisions of the California ESA.

### 1.4.5 Porter-Cologne Water Quality Control Act

Under this Act (California Water Code Sections 13000–14920), the RWQCB is authorized to regulate the discharge of waste that could affect the quality of the State's waters. Therefore, even if a project does not require a federal permit, it may still require review and approval by the RWQCB (e.g., for impacts to isolated wetlands and other waters). When reviewing applications, the RWQCB focuses on ensuring that projects do not adversely affect the "beneficial uses" associated with waters of the State. In most cases, the RWQCB seeks to protect these beneficial uses by requiring the integration of water quality control measures into projects that will require discharge into waters of the State. For most construction projects, the RWQCB requires the use of construction and post-construction best management practices (BMPs).

### 1.4.6 California Fish and Game Code

The CDFG is also responsible for enforcing the California Fish and Game Code, which contains several provisions potentially relevant to construction projects. For example, Section 1602 of the Fish and Game Code (CCR; Title 14, Div. 1) governs the issuance of Lake and Streambed Alteration Agreements by the CDFG. Lake and Streambed Alteration Agreements are required whenever project activities substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake designated as such by the CDFG. Section 1602 of the Fish and Game Code applies to all perennial, intermittent, and ephemeral rivers, streams, and lakes in the state.

The Fish and Game Code also lists animal species designated as Fully Protected, which may not be taken or possessed at any time. The Fully Protected designation does not allow "incidental take" and is thus more restrictive than the CESA. Fully Protected species are listed in Sections 3511 (birds), 4700 (mammals), 5050 (reptiles and amphibians), and 5515 (fish) of the Fish and Game Code, while protected amphibians and reptiles are listed in Chapter 5, Sections 41 and 42 (CCR; Title 14, Div. 1). Section 3503 of the Fish and Game Code (CCR; Title 14, Div. 1) prohibits the take, possession, or needless destruction of the nest or eggs of most bird species. Subsection 3503.5 (CCR; Title 14, Div. 1) specifically prohibits the take, possession, or destruction of any birds in the orders Falconiformes (hawks and eagles) or Strigiformes (owls) and their nests. These provisions, along with the federal MBTA, essentially serve to protect nesting native birds. Certain non-native species, including European starling and house sparrow, are not protected under the MBTA or California Fish and Game Code.

### 1.4.7 California Environmental Quality Act

CEQA applies to "projects" proposed to be undertaken or requiring approval by State or local governmental agencies. Projects are defined as having the potential to have a physical impact on the environment and requiring a discretionary decision by a public agency. Under Section 15380 of the CEQA Guidelines, a species not included on any formal list "shall nevertheless be considered rare or endangered if the species can be shown by a local agency to meet the criteria" for listing. With

sufficient documentation, a species could be shown to meet the definition of rare or endangered under CEQA, which would lower the threshold of significance for project impacts.

### 1.4.8 California Species of Special Concern

The CDFG maintains an administrative list of Species of Special Concern (SSC), defined as a "species, subspecies, or distinct population of an animal native to California that currently satisfies one or more of the following (not necessarily mutually exclusive) criteria:

- is extirpated from the State, or, in the case of birds, in its primary seasonal or breeding role;
- is listed as federally, but not State, threatened or endangered;
- meets the State definition of threatened or endangered but has not formally been listed;
- is experiencing, or formerly experienced, serious (noncyclical) population declines or range retractions (not reversed) that, if continued or resumed, could qualify it for State threatened or endangered status; and
- has naturally small populations exhibiting high susceptibility to risk from any factor(s), that if realized, could lead to declines that would qualify it for State threatened or endangered status."

The CDFG's Nongame Wildlife Program is responsible for producing and updating SSC publications for mammals (Williams 1986); birds (Shuford and Gardali 2008); and reptiles and amphibians (Jennings and Hayes 1994). The Fisheries Branch is responsible for updates to the Fish SSC document and list (Moyle et al. 1995). Section 15380 of the CEQA Guidelines clearly indicates that SSC should be included in an analysis of project impacts if they can be shown to meet the criteria of sensitivity outlined therein. In contrast to species listed under the federal or California ESAs, however, SSC have no formal legal protective status.

### 1.4.9 California Rare Plant Ranks

Special-status plants in California are assigned to one of five "California Rare Plant Ranks" by a collaborative group of over 300 botanists in government, academia, non-governmental organizations, and the private sector. This effort is jointly managed by the CDFG and the non-profit California Native Plant Society (CNPS). The five California Rare Plant Ranks currently recognized by the CNDDB include the following:

- Rare Plant Rank 1A – presumed extinct in California.
- Rare Plant Rank 1B – rare, threatened, or endangered in California and elsewhere.
- Rare Plant Rank 2 – rare, threatened, or endangered in California but more common elsewhere.
- Rare Plant Rank 3 – a review list of plants about which more information is needed.
- Rare Plant Rank 4 – a watch list of plants of limited distribution.

Substantial impacts to plants ranked 1A, 1B, and 2 are typically considered significant based on Section 15380 of the CEQA Guidelines depending on the policy of the lead agency. Plants ranked 3

and 4 may be evaluated by the lead agency on a case-by-case basis to determine significance thresholds under CEQA.

### 1.4.10 San Francisco Urban Forestry Ordinance

The San Francisco Urban Forestry Ordinance (i.e., Article 16 of the San Francisco Public Works Code) was enacted to ensure the protection of trees on private land within and adjacent to public areas. The City and County of San Francisco currently considers "Protected Trees" as street trees, significant trees, and landmark trees. These tree types are defined as follows:

- Landmark trees have the highest level of protection in the City, and meet criteria for age, size, shape, species, location, historical association, visual quality, or other contribution to the City's character and have been found worthy of landmark status after public hearings at both the Urban Forestry Council and the Board of Supervisors. Temporary landmark status is also afforded to nominated trees currently undergoing the public hearing process.
- Significant trees are those that are within 10 feet of the property edge of the sidewalk that are above 20 feet in height, or with a canopy greater than 15 feet in diameter, or with a trunk diameter greater than 12 inches in diameter at breast height (DBH).
- Street trees are trees within the public right-of-way. Street trees may be maintained by either the adjacent property owner or the City.

Removal of any of these trees on private land is not prohibited but requires a permit from the Department of Public Works, subject to review against certain criteria and public notification. If any construction activity is to occur within the dripline of any protected tree, a tree protection plan prepared by an International Society of Arboriculture (ISA)-certified arborist must be submitted to the Planning Department for review and approval prior to the issuance of a building permit. All permit applications that could potentially impact a protected tree must include a Planning Department "Tree Disclosure Statement" form, which constitutes the applicant's legal declaration of all trees on the property. As part of the Tree Disclosure Statement, applicants must identify and show accurately the size of the trunk diameter and canopy dripline in relation to the proposed project on site plans. The Reserve is not privately owned. It is designated permanent open space by The Regents of the University of California, and is open to the public. Additionally, UCSF is constitutionally exempt from local jurisdiction regulations whenever using property under its control in support of its educational mission. Therefore, UCSF would not be subject to this Ordinance.

# 2.0 METHODS

Prior to visiting the site, LSA searched the California Natural Diversity Database (CNDDB) (CDFG 2010) for records of special-status species (including non-vascular plants) occurrences within 5 miles of the Reserve using Geographic Information Systems (GIS) software (ArcGIS 9.3.1). LSA also searched the CNPS *Inventory of Rare and Endangered Plants* (CNPS 2010) for special-status plant occurrences within the San Francisco North and San Francisco South U.S. Geological Survey (USGS) 7.5-minute quadrangles, and reviewed the *Consortium of California Herbaria*[1] for observations or collections of special-status plant species within the surrounding area. Other sources of information included the *Mount Sutro Open Space Reserve Management Plan* (EDAW 2001), the preliminary *San Francisco Breeding Bird Atlas* (SFFO 2003) prepared by San Francisco Field Ornithologists (SFFO), and the Mount Sutro Stewards, who made their accumulated records and observations of plants and animals available to LSA for preparation of this report.

LSA biologists Richard Nichols, Matt Ricketts, and Tim Milliken conducted an initial reconnaissance-level survey of the project area on July 12, 2010 to document existing habitat conditions, record information on plant and animal species, and assess each of the project areas for their potential to support special-status plant and/or animal species (see definition below). Mr. Ricketts conducted a follow-up wildlife survey on the morning of July 27, 2010 and Mr. Milliken conducted a focused botanical survey on August 13, 2010. Wildlife species (mostly birds) were identified both aurally (i.e., listening for calls and songs) and visually using binoculars. Since amphibians, reptiles, and mammals are less detectable than birds, potentially occurring species from these taxa were identified by noting the existing habitat conditions on the Reserve and assessing the potential for such species to occur based on their known habitat requirements as published in the literature or as observed by LSA biologists in other parts of the San Francisco Bay region.

For the purposes of this study, special-status species are defined as follows:

- Species that are listed, formally proposed, or designated as candidates for listing as threatened or endangered under the federal ESA
- Species that are listed, or designated as candidates for listing, as rare, threatened, or endangered under the California ESA
- Plant species assigned to California Rare Plant Ranks 1A, 1B, and 2
- Animal species designated as Species of Special Concern or Fully Protected by the CDFG
- Species that meet the definition of rare, threatened, or endangered under Section 15380 of the CEQA guidelines
- Considered to be a taxon of special concern by relevant local agencies

[1] The Consortium of California Herbaria (Consortium) database is provided by the participants of the Consortium of California Herbaria (ucjeps.berkeley.edu/consortium/).

Plant taxonomy and nomenclature in this report follows those of Hickman (1993) Beidleman and Kozloff (2003), Doyle and Stotler (2006), Esslinger (2009), and Norris and Shevock (2004a, 2004b). Vegetation types were classified in accordance with the second edition of *A Manual of California Vegetation* (Sawyer et al. 2009). Common and scientific names for special-status species or subspecies conform to the CNDDB (CDFG 2010). Common and scientific names for herpetofauna (i.e., amphibians and reptiles), birds, and mammals conform to Crother (2008), the American Ornithologists' Union (AOU) *Check-list of North American Birds* (AOU 1998), and Baker et al. (2003), respectively.

# 3.0 BIOLOGICAL SETTING

## 3.1 VEGETATION

For the purposes of this study, vegetation types on the Reserve were classified, to the greatest extent possible, according to *A Manual of California Vegetation*, Second Edition (Sawyer et al. 2009), which is based on the National Vegetation Classification Hierarchy. The lower levels of the hierarchy are the focus of this report. Alliances have both a common and scientific name; in the discussion below the common name of the alliance appears first and the scientific follows in parentheses. Alliances and Semi-Natural Stands are defined and named by the dominant species; however, many alliances exhibit variation in subdominant species composition and structure. Sawyer et al. (2009) refer to these variations in species composition and structure as Associations. Each vegetation type has at least one association, but many of these have complex associations that are not easily described. Sawyer et al. (2009) also identify semi-natural stands; these are vegetation types dominated by non-native species that have become naturalized in California.

The majority of vegetation within the Reserve consists of dense eucalyptus forest that is best described as Eucalyptus Groves (*Eucalyptus* Semi-Natural Woodland Stands) with a dense understory of English ivy (*Hedera helix*), and Himalayan Blackberry Brambles (*Rubus armeniacus* Semi-Natural Stands) using the terminology of Sawyer et al. (2009) (Figure 3). Throughout the Reserve are remnants of Coastal Brambles (*Rubus* sp. Shrubland Alliance), a native vegetation type that is expressed as scattered stands of variable purity. The summit clearing (i.e., Rotary Native Plant Garden) formerly consisted of a dense stand of the invasive French broom (*Genista monspessulana*), but has since been converted to Coyote Brush Scrub (*Baccharis pilularis* Shrubland Alliance) due to restoration efforts by the Mount Sutro Stewards in the early 2000s. Each of these vegetation types is briefly described below. Himalayan Blackberry Brambles and Coastal Brambles are not depicted on Figure 3 since they occur in the understory of the eucalyptus forest and are not discernable at the scale depicted. Non-vascular flora (e.g., lichens and mosses) are also briefly discussed.

### 3.1.1 Eucalyptus Groves (*Eucalyptus* Semi-Natural Woodland Stands)

Eucalyptus Groves are dominated by one or several of at least nine eucalyptus species known to occur in California. The eucalyptus forest that covers the majority of the Reserve is primarily a monotypic stand dominated by blue gum eucalyptus (*Eucalyptus globulus*) with an average trunk size of single leader trees ranging from 24–42 inches in basal diameter. The largest trees range in height from approximately 150 to 200 feet. Branching in most of these trees occurs at 50 to 75 feet above the ground, providing a fairly open canopy. Larger blue gum trees are widely spaced throughout the forest, suggesting that they were among those originally planted in the late 1880s. Smaller blue gum trees approximately 30 to 50 feet tall are more closely spaced and are more abundant than the larger trees. Occasional Monterey cypress (*Callitropsis macrocarpa*) and Monterey pine (*Pinus radiata*) trees are scattered throughout the forest, and several large coast redwoods have been planted near the main UCSF campus on the north side of the Reserve. These trees occasionally reach heights and basal diameters similar to those of blue gum.

LSA

FIGURE 3

LEGEND

Study Area

Coyote Brush Scrub

Eucalyptus Grove

N

0 200 400

FEET

*Mount Sutro Open Space Reserve, UCSF*

Vegetation Types

SOURCE: Aerial Imagery from Digital Globe, May 2009.

I:\USF1001\GIS\Maps\Figure3_Vegetation.mxd (8/23/2011)

The middle canopy of the forest is comprised of blackwood acacia (*Acacia melanoxylon*), flowering plums (*Prunus* sp.), red elderberry (*Sambucus racemosa*), and smaller coast redwoods planted near the Surge and Woods Buildings. The redwoods range in size from 6 to 8 inches in diameter and are approximately 40 feet tall.

The majority of the forest understory is dominated by dense thickets of English ivy, German ivy (*Delairea oderata*), garden nasturtium (*Tropaeolum majus*), and Himalayan blackberry (*Rubus armeniacus*), all of which are considered invasive non-native species (Cal-IPC 2006). English ivy is a dominant component throughout the entire forest understory, sprawling over the ground and climbing some tree trunks up to 50 feet aboveground. Native understory species are limited to occasional patches of honeysuckle vines (*Lonicera hispidula*), sword ferns (*Polystichum munitum*), and California blackberry (*Rubus ursinus*).

### 3.1.2 Himalayan Blackberry Brambles (*Rubus armeniacus* Semi-Natural Sands)

Although the majority of the forest understory is as described above, the abundance of Himalayan blackberry is worthy of mentioning separately due to its high invasive species ranking by the California Invasive Plant Inventory (Cal-IPC 2009). Himalayan Blackberry Brambles form impenetrable stands throughout the Reserve and often intermix with stands of California blackberry and poison oak, both of which are native.

### 3.1.3 Coastal Brambles (*Rubus* sp. Shrubland Alliance)

Himalayan Blackberry Brambles may be confused with California blackberry in stands of Coastal Brambles (*Rubus parviflorus, R. spectablis, R. ursinus* Shrubland Alliance). This native vegetation type was likely dominant on the headlands and exposed slopes of the Reserve prior to the late 1880s. Species typical of this vegetation type include bee plant (*Scrophularia californica*), twinberry (*Lonicera involucrata*), wild cucumber (*Marah fabaceous*), red elderberry, coyote brush, poison oak, and sword fern. California blackberry and many of the associated species are common throughout the Reserve.

### 3.1.4 Coyote Brush Scrub (*Baccharis pilularis* Shrubland Alliance)

The Rotary Native Plant Garden most closely resembles the vegetation type described by Sawyer et al. (2009) as Coyote Brush Scrub (*Baccharis pilularis* Shrubland Alliance) as a result of habitat restoration efforts in the early 2000s. Native shrubs present include California sagebrush (*Artemesia californica*), sticky monkeyflower (*Mimulus aurantiacus*), mugwort (*Artemesia douglasii*), lizard tail (*Eriophyllum staechadifolium*), cow parsnip (*Heracleum lanatum*), yellow bush lupine (*Lupinus arboreus*), and coyote brush. Small remnants of the non-native invasive French broom are also present despite efforts to remove it. A few coast live oaks (*Quercus agrifolia*) have been planted around the clearing; other trees or large shrubs planted as part of the restoration effort include California buckeye (*Aesculus californica*), toyon (*Heteromeles arbutifolia*), California waxmyrtle (*Morella californica*), and red elderberry. Native herbaceous vegetation observed includes yarrow (*Achillea millefolium*), blue wild rye (*Elymus glaucus*), woodland strawberry (*Fragaria vesca*), and bee plant.

### 3.1.5 Non-Vascular Flora

**Bryophytes.** Bryophytes (commonly known as mosses and liverworts) can occur on all habitat and substrate types present on the Reserve. Although distributions are not well known for special-status bryophytes, the record search for plants revealed documentation of two occurrences of coastal triquetrella (*Triquetrella californica,* Rare Plant Rank 1B) in the immediate vicinity of the Reserve. Occurrence #4 is approximately 0.5 mile to the east at Tank Hill, and occurrence #3 consists of three observations at various open space sites between 1.1 and 1.7 miles east of the Reserve. Given the proximity of these records and the presence of suitable habitat on the Reserve (open gravels on roadsides, hillsides, and rocky slopes in coastal scrub), this species has the potential to occur in the project area. LSA collected bryophyte samples from various parts of the Reserve. All bryophytes collected were identified to the species level. None were identified as special-status species by LSA, nor were any of the prior collections from Mount Sutro (Norris and Shevock 2004a). However, special-status bryophytes could still occur in areas that were not sampled. A listing of all bryophyte taxa identified on the site is included in Appendix A.

**Fungi.** Fungi (commonly known as mushrooms) are organisms typically treated as plants, and are studied by botanists (mycologists), though they belong to a different taxonomic kingdom. Fungi are important organisms in ecosystems because they assist in the natural processes of decomposition and nutrient cycling. Mycorrhizae are specialized fungi that associate with plant roots and assist in the uptake of water and essential mineral nutrients. Fungi also have recreational values because many people are interested in hunting for edible mushrooms. Many species of fungi are responsible for a wide variety of plant diseases including pitch pine canker (*Verticillium subglutinans*), root rot (*Armillaria mellea*), artist's conk (*Ganoderma applanatum*), sulfur fungus (*Laetiporus sulphurens*), turkey tail (*Trametes hirsuta*), and tree anthracnose (*Colletotrichum gloeosporioides, Discula fraxinea).* Sudden oak death is caused by a slime mold (*Phytophthora ramorum*), which is not a true fungi. Currently there is no regulatory protection afforded to fungi in California, therefore none are listed on the CNDDB. Although only a few fungi were identified on the site (Appendix A), many more species of fungi are undoubtedly present on the Reserve.

**Lichens.** Lichens are organisms composed of a fungus and algae growing together in a symbiotic relationship. They occur in association with habitats and substrate types present in the project area. Although the record search for plants did not reveal any occurrence of special-status lichens within a 10-mile radius of the site, a further radius search shows two special-status lichen species occurring in coastal Sonoma County: whiteworm lichen (*Thamnolia vermicularis*), and Methusela's beard lichen (*Usnea longissima*). The physiographic and climatic requirements of these two species do not occur on the Reserve: Sonoma County populations of whiteworm lichen only occur on windswept slopes close to sea level and Methusela's beard lichen is generally known from non-disturbed coastal coniferous rain forests (Brodo 2001). The surveys included a collection of lichen specimens from the site that were identified to species. No special-status lichens were found during the brief surveys, nor are they expected to occur here due to lack of suitable habitat. A listing of all lichen taxa identified on the site is included in Appendix A.

### 3.1.5 Epiphytic Flora

Plants that live upon trunk and bark surfaces of trees or other plants are called epiphytes. The eucalyptus forest at the Reserve supports a wide variety of epiphytes including mosses, lichens, and

ferns. Leather fern (*Polypodium scouleri*) was observed growing as an epiphyte on eucalyptus, blackwood acacia, and Monterey cypress trunks and branches up to 30 feet above the forest floor. These observations indicate that epiphytes are non-specific when selecting host species as long as environmental factors suitable to their dispersal and establishment are present (i.e., fog drip, wind, and textured bark). No other epiphytes were observed during the surveys.

## 3.2 WILDLIFE

Many of the wildlife species expected to occur at the Reserve are generalists that have adapted to the urban environment and are able to co-exist with humans. Species observed by LSA during the two site visits are listed in Appendix A. Most of the species detected were birds, since they are more visible, numerous, and widely distributed than amphibians, reptiles, and mammals. Each of these taxonomic groups are described in more detail below. Given the increased interest in insects, including butterflies, by many amateur naturalists, a brief discussion of common species expected to occur on the Reserve is also provided.

### 3.2.1 Insects

Native insect diversity within the Reserve is expected to be low because of the dominance of non-native eucalyptus. Eucalyptus covers the majority of the site except the Rotary Native Plant Garden at the summit that has been restored with native plant species. Due to increased sunlight exposure, the insect fauna of the Rotary Native Plant Garden would differ from that of the shaded understory of the eucalyptus forest, but is expected to be low in diversity because of the garden's small size and isolation.

Butterflies and bees would be expected to occur in the Rotary Native Plant Garden. The occurrence of some butterfly species would depend on the presence of their larval host plants or adult nectar plants, while other species would be transient and may fly through the Reserve. Species likely to be transient are monarch butterflies (*Danaus plexxipus*), swallowtails (*Papilio* spp.), orange sulphur (*Colias eurytheme*), and painted ladies (*Vanessa virginiensis*, *V. cardui*, *V. annabella*). Widespread and common species of butterflies that are likely to be resident if their larval food plants are sufficiently abundant are the cabbage white (*Pieris rapae*), common hairstreak (*Strymon melinus*), buckeye, (*Junonia coenia*), and umber skipper (*Poanes melane*).

Bumblebees (*Bombus* spp.), a few other species of native bees, and non-native honey bees (*Apis mellifera*), would be expected to forage for nectar or pollen on the flowers growing in the Rotary Native Plant Garden and the adjacent understory. Bumblebees and most of the other native bees construct nests in the ground, a few native bee species construct their nests in twigs, and non-native honey bees would build their hives in hollow tree trunks.

The insect fauna of the shady understory of the eucalyptus forest would include moths, flies and beetles. Moths would use native shrubs as larval food plants. Many species of flies are adapted to shady habitats where their larvae feed on decaying vegetation in moist leaf litter. The beetles would occur beneath fallen logs, within the leaf litter, or in the open. The beetles present would include those in the families Carabidae, Tenebrionidae, and many others and the beetle species would be carnivores, herbivores, or detritivores. Two species of eucalyptus borer (*Phoracantha semipunctata*

and *Phoracantha recurva*) may also occur in the eucalyptus trees of Mt. Sutro, where their larvae eat the inner bark. Heavy infestations of these species may kill eucalyptus trees.

### 3.2.2 Amphibians and Reptiles

Although no amphibians or reptiles were observed during the site visits, the dense understory and leaf litter in the eucalyptus forest is likely to support common, urban-adapted species such as California slender salamander (*Batrachoseps attenuatus*), southern alligator lizard (*Elgaria multicarinatus*), Sierran treefrog (*Pseudacris sierra*), and common garter snake (*Thamnophis sirtalis*). Sunny, open areas with rock outcrops or other hard surfaces (e.g., at the summit) may support western fence lizards (*Sceloporus occidentalis*).

### 3.2.3 Birds

The dense understory that characterizes much of the eucalyptus forest provides suitable nesting habitat for ground- and shrub-nesting species such as Pacific wren[2] (*Troglodytes pacificus*), song sparrow (*Melospiza melodia*), and dark-eyed junco (*Junco hyemalis*). The Reserve is also one of the few sites in the City that support breeding Pacific-slope flycatchers (*Empidonax difficilis*), Swainson's thrushes (*Catharus ustulatus*), and Wilson's warblers (*Wilsonia pusillula*), all of which occur in moist drainages with scattered canopy openings that allow sunlight to penetrate to the forest floor such as the East Bowl Corridor (J. Clark, pers. comm.). Olive-sided flycatcher (*Contopus cooperi*), a California Species of Special Concern and uncommon summer resident, was detected in the lower portion of the East Bowl Corridor during LSA's surveys and occurs on the Reserve every year, although its breeding success is constrained by common raven (*Corvus corax*) predation (J. Clark, pers. comm.). Cavity-nesting species such as downy woodpecker (*Picoides pubescens*), chestnut-backed chickadee (*Poecile rufescens*), brown creeper (*Certhia americana*), and pygmy nuthatch (*Sitta pygmaea*) likely nest in the forest in dead trees, snags, and trees with soft bark such as Monterey cypress. Scattered large trees throughout the Reserve provide suitable nest sites for urban-adapted raptors such as great horned owl (*Bubo virginianus*), red-shouldered hawk (*Buteo lineatus*), and Cooper's hawk (*Accipiter cooperi*).

The diverse native shrubs and open character of the Rotary Native Plant Garden at the summit clearing provides optimal habitat for Anna's (*Calypte anna*) and Allen's (*Selasphorus sasin*) hummingbird, both of which were abundant in the area during LSA's site visits. The summit clearing was also the only place on the Reserve where Allen's hummingbird and orange-crowned warbler (*Oreothlypis celata*) were observed, likely due to its open habitat structure. Both of these species are known to breed on the Reserve (J. Clark, pers. comm.).

During the winter, the resident bird community is augmented by species that breed further north or at higher elevations such as ruby-crowned kinglet (*Regulus calendula*), hermit thrush (*Catharus guttatus*), yellow-rumped warbler (*Dendroica coronata*), Townsend's warbler (*Dendroica townsendi*), and fox sparrow (*Passerella iliaca*). Mount Sutro is also one of several "islands" of vegetation in San Francisco that provide stopover habitat for migrant songbirds in the spring and fall.

[2] The common and scientific name of this species was recently changed from winter wren (*Troglodytes troglodytes*) to Pacific wren (*Troglodytes pacificus*) in the 51st supplement to the AOU *Check-list of North American Birds*.

Some of the more regular migrants likely to occur include warbling vireo (*Vireo gilvus*), black-throated gray warbler (*Dendroica nigrescens*), yellow warbler (*Dendroica petechia*), western tanager (*Piranga ludoviciana*), and black-headed grosbeak (*Pheucticus melanocephalus*). In summary, the Reserve provides habitat values for a variety of both resident and migratory bird species, including several that are locally uncommon or rare in San Francisco such as Pacific-slope flycatcher, Hutton's vireo, Pacific wren, Swainson's thrush, Wilson's warbler, and orange-crowned warbler (J. Clark, pers. comm.).

### 3.2.4 Mammals

Eastern fox squirrel (*Sciurus niger*) was the only mammal species observed during LSA's site visits, although other urban-adapted species such as Virginia opossum (*Didelphis virginiana*), deer mouse (*Peromyscus maniculatus*), house mouse (*Mus musculus*), northern raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and black-tailed deer (*Odocoileus hemionus*) are also expected to occur. Little is known about the status and distribution of bats in urban San Francisco, but species common to the Bay Area such as big brown bat (*Eptesicus fuscus*), Brazilian free-tailed bat (*Tadarida brasiliensis*), and Yuma myotis (*Myotis yumanensis*) likely forage on the Reserve. Migratory tree-roosting species such as hoary bat (*Lasiurus cinereus*) may occasionally roost in the on-site trees during migration, especially considering the site's proximity to the Pacific coastline.

## 3.3 SPECIAL-STATUS SPECIES

### 3.3.1 Plants

Based on a review of the CNDDB (CDFG 2010) and the CNPS *Electronic Inventory of Rare and Endangered Plants of California* (CNPS 2010), LSA identified 22 special-status plant species as potentially occurring in the general site vicinity (Table A). With the exception of San Francisco gumplant (*Grindelia hirsutula* var. *maritima*), coastal triquetrella (*Triquetrella californica*), none of these are expected to occur due to a lack of suitable habitat (i.e., tidal salt marsh, brackish marsh, coastal dunes, serpentine soils). San Francisco gumplant and coastal triquetrella are briefly discussed below.

**San Francisco Gumplant.** San Francisco gumplant is a plant with a California Rare Plant Rank of 1B. This species is considered rare in California where it occurs in coastal scrub and bluffs from San Luis Obispo County to Marin County (Consortium 2010). The closest extant record (CNDDB occurrence #2) is attributed to a location on the west slope of Mount Sutro on San Francisco Public Utilities Commission land adjacent to Laguna Honda (J. Sigg, pers. comm.). Although this population is on the Mount Sutro Stewards plant list, it is outside of the Reserve and isolated from it by urban development. Suitable habitat for this species occurs on the Reserve in coyote brush scrub and associated grassland habitat in the Rotary Garden.

**Coastal Triquetrella.** Coastal triquetrella is a moss with a California Rare Plant Rank of 1B. This moss species is considered rare in California and is known from fewer than ten small coastal occurrences (CNPS 2010). Coastal triquetrella forms loose mats on exposed to shaded soil, rocks, sand, or gravel in dry or moist situations. The closest extant record (CNDDB occurrence #4) is located less than 0.1 mile from the site on Tank Hill. Although this moss was not observed during the fieldwork, it may be present with other mosses on soil, gravels and rocks along trail sides, and within grassy areas with rocks.

## Table A: Special-status Species Potentially Occurring in the Vicinity of the Mount Sutro Open Space Reserve, San Francisco, California

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| **PLANTS** | | | |
| *Amsinckia lunaris*<br>Bent-flowered fiddleneck | 1B | Annual grasslands. Blooms April to May. 3–500 meters. | Closest record (CNDDB occurrence #6) is located approximately 6.3 air miles to the south at San Bruno Mountain. The likelihood of this species occurring on the Reserve is low due to the density of and competition from exotic vegetation. |
| *Arctostaphylos franciscana* | 1B | Serpentine outcrops in chaparral. 60-300 meters. | Considered extinct until one plant was discovered during a road construction project in the Presidio of San Francisco. Highly unlikely to occur on the Reserve due to lack of suitable serpentine habitat. |
| *Arctostaphylos hookeri* ssp. *ravenii*<br>Presidio manzanita | FE, SE, 1B | Chaparral, coastal prairie, coastal scrub/serpentinite outcrop. Blooms February to March. 45–215 meters. | Closest extant record (CNDDB occurrence #4) is attributed to a reintroduction of the plant at Baker's Beach near the WWII Memorial, approximately 2.6 miles from the Reserve. Not expected to occur due to lack of suitable habitat. |
| *Arctostaphylos imbricata*<br>San Bruno manzanita | SE, 1B | Chaparral or coastal scrub on San Bruno Mountain; mostly known from a few sandstone outcrops<br>Blooms February to May. 275–370 meters. | Not expected to occur due to lack of suitable habitat; species distribution limited to San Bruno Mountain. |
| *Arctostaphylos montaraensi*<br>Montara manzanita | 1B | Coastal chaparral, coastal scrub. Blooms January to March. 150–500 meters. | Closest record (CNDDB occurrence #8) is located approximately 4.9 air miles to the south near the summit of San Bruno Mountain. The likelihood of this species occurring on site is low due to the density of competing non-native vegetation. |
| *Arctostaphylos pacifica*<br>Pacific manzanita | SE, 1B | Coastal scrub associated with sandstone and other species of *Arctostaphylos*. Known only from San Bruno Mountain. Blooms February to April. | Closest record (CNDDB occurrence #1) is located approximately 5.3 air miles to the south near the summit of San Bruno Mountain. Not expected to occur; species distribution limited to San Bruno Mountain. |
| *Cirsium andwersii*<br>Franciscan thistle | 1B | Coastal bluff scrub, coastal prairie, broadleafed upland forest; sometimes occurs in serpentine seeps. Blooms March to July. 0-150 meters. | Closest presumed extant record (CNDDB occurrence #7) is approximately 1.9 miles to the north near Mountain Lake in the Presidio. Not expected to occur due to disturbance and lack of suitable habitat. |
| *Cirsium occidentale var. compactum*<br>Compact cobwebby thistle | 1B | Chaparral, coastal dunes, coastal prairie, coastal scrub. Blooms April to June. 5–150 meters. | Closest possibly extirpated record (CNDDB occurrence #15) approximately 2.7 miles to the south near Lake Merced. Not expected to occur due to prior disturbance and lack of suitable habitat |
| *Clarkia franciscana*<br>Presidio clarkia | FE, SE, 1B | Coastal scrub, valley and foothill grassland, sometimes on serpentine. Blooms May to July. 25–335 meters. | Closest presumed extant record (CNDDB occurrence #2) is attributed to a reintroduction of the plant to serpentine grasslands at the Presidio approximately 1.9 miles to the north. Not expected to occur due to lack of suitable habitat. |
| *Collinsia corymbosa*<br>Round-headed Chinese-houses | 1B | Coastal dunes. Blooms April to June. 0–20 meters. | Closest presumed extant record (CNDDB occurrence #1) is attributed to a collection made in 1902 at the Presidio approximately 1.1 miles to the north. Not expected to occur due to lack of suitable habitat. |

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| *Collinsia multicolor*<br>San Francisco collinsia | 1B | Closed-cone coniferous forest, coastal scrub and grassland on decomposed shale (mudstone) mixed with humus. Sometimes on serpentinite. Blooms March to May. 30–250 meters. | Closest presumed extant record (CNDDB occurrence #16) is attributed to a collection made in 1929 at Glen Canyon Park approximately 0.6 miles to the southeast. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Fritillaria liliacea*<br>Fragrant fritillary | 1B | Grasslands in coastal scrub and coastal prairie, often on serpentine and usually in clay soils but various soil types are reported. Blooms February to April. 3–410 meters. | Closest presumed extant record (CNDDB occurrence #61) is attributed to an observation mentioned in an undated article by Mike Wood. The location is from the Twin Peaks area approximately 0.3 miles to the south. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Grindelia hirsutula* var. *maritima*<br>San Francisco gumplant | 1B | Coastal scrub, grassland; sandy or serpentine slopes, sea bluffs, valley and foothill grassland. Blooms June to September. 15–400 meters. | Closest extant record (CNDDB occurrence #2) is attributed to a location on the west slope of Mount Sutro outside of the Reserve. Although this plant is on the Mount Sutro Stewards plant list, the known population is isolated from the Reserve habitat and it was not observed on the Reserve during LSA surveys. |
| *Helianthella castanea*<br>Diablo helianthella | 1B | Thin, rocky soils on grassy hillsides and in cismontane woodland, usually at the scrub/chaparral/oak woodland interface. Blooms April to May. 150–1,220 meters. | Closest presumed extant record (CNDDB occurrence #11) is attributed to a collection made in 1899 at Bay View Hill approximately 3.6 miles to the southeast. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Hesperolinon congestum*<br>Marin western flax | FT, ST, 1B | Chaparral, valley and foothill grassland/serpentinite. Blooms April to July. 5–370 meters. | Closest extant record (CNDDB occurrence #16) is attributed to an attempted reintroduction at Baker Beach, approximately 2.6 miles to the north. Not expected to occur due to lack of suitable habitat. |
| *Pentachaeta bellidiflora*<br>White-rayed pentachaeta | FE, ST, 1B | Cismontane woodland valley and foothill grassland, often on open, dry rocky slopes. Blooms March to May. 35–620 meters. | The closest record (CNDDB #6) is from the east edge of San Bruno Mountain, approximately 6.5 air miles to the south-southeast. Not expected to occur due to lack of suitable habitat. |
| *Plagiobothrys chorisianus var. chorisianus*<br>Choris' popcorn-flower | 1B | Chaparral, coastal prairie, coastal scrub, mesic sites. Blooms March to June. 15–160 meters. | Closest presumed extant record (CNDDB occurrence #12) is approximately 0.2 miles to the north in Golden Gate Park as documented in the *Flora of San Francisco*. Not expected to occur due to prior disturbance and lack of suitable habitat |
| *Plagiobothrys diffusus*<br>San Francisco popcorn flower | SE, 1B | Coastal prairie, valley and foothill grassland. Blooms March to June. 60–360 meters. | Closest presumed extant record (CNDDB occurrence #2) is approximately 1.7 miles to the north on clay flats near Mountain Lake in the Presidio. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Polemonium carneum*<br>Oregon polemonium | 2 | Coastal prairie, coastal scrub, lower montane coniferous forest. Blooms April to September. 0–1,830 meters. | Closest presumed extant record (CNDDB occurrence #5) is attributed to a 1939 collection from Point Bonita in Marin County, approximately 4.4 miles to the north. Not expected to occur due to prior disturbance and lack of suitable habitat. |
| *Silene verecunda* ssp. *verecunda*<br>San Francisco campion | 1B | Coastal bluff scrub, grassland, chaparral, coastal prairie, sandy areas in valley and foothill grassland. Blooms March to June. 30–645 meters. | Closest presumed extant record (CNDDB occurrence #8) is approximately 1 mile south of the Reserve at Mt. Davidson. This population is on rock slopes of Franciscan greywacke, threatened by blue gum eucalyptus and German ivy. Not expected to occur due to prior disturbance and lack of suitable habitat. |

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| *Stebbinsoseris decipiens*<br>Santa Cruz microseris | 1B | Broadleafed upland forest, closed-cone coniferous forest, chaparral, coastal prairie, coastal scrub, often in open areas and sometimes serpentinite in valley and foothill grassland. Blooms April to May. 10-500 meters. | Closest record (CNDDB occurrence #18) is approximately 7.3 air miles to the north on Angel Island. Not expected to occur due to lack of suitable habitat. |
| *Triphysaria floribunda*<br>San Francisco owl's-clover | 1B | Coastal prairie, coastal scrub, usually on serpentine in valley and foothill grassland. Blooms April to June. 10–160 meters. | Closest extant record (CNDDB occurrence #19) is attributed to a declining population at the Presidio, approximately 2.6 miles to the north. Not expected to occur due to lack of suitable habitat. |
| *Triquetrella californica*<br>Coastal triquetrella | 1B | Coastal bluff scrub, on soil in coastal scrub. 10–100 meters. | Closest extant record (CNDDB occurrence #4) is located less than 0.1 mile from the Reserve on Tank Hill. Like other mosses, coastal triquetrella grows over rocks, on soil, and within grassy areas with rocks. Although this moss was not observed during the fieldwork, it could have easily been overlooked and may be present on the project site. |
| **ANIMALS** | | | |
| San Bruno elfin butterfly<br>*Callophrys mossii bayensis* | FE | Coastal mountains with grassy ground cover, mainly in the vicinity of San Bruno Mountain; colonies located on steep, north-facing slopes in fog belt; host plant is *Sedum spathulifolium*. | Not expected to occur due to lack of suitable larval food plant and habitat; species distribution limited to San Bruno Mountain |
| Mission blue butterfly<br>*Plebejus icarioides missionensis* | FE | Grasslands of the San Francisco peninsula; three larval host plants: *Lupinus albifrons*, *L. variicolor*, and *L. formosus*. | Not expected to occur due to lack of suitable larval food plant and habitat. |
| Callippe silverspot butterfly<br>*Speyeria callippe callippe* | FE | Coastal scrub of the San Francisco peninsula; host plant is *Viola pedunculata*, most adults found on east-facing slopes. | Not expected to occur due to lack of suitable larval food plant and habitat. |
| Monarch butterfly (wintering roosts)<br>*Danaus plexippus* | CEQA | Protected areas in groves of trees with dense canopy cover and nearby water and nectar sources. | May occur. Dense eucalyptus in sheltered portions of Reserve provide suitable habitat. |
| California red-legged frog<br>*Rana draytonii* | FT, CSC | Ponds, streams, drainages and associated uplands; requires areas of deep, still, and/or slow-moving water for breeding. | Not expected to occur due to lack of suitable aquatic habitat. |
| Western pond turtle<br>*Actinemys marmorata* | CSC | Ponds, streams, drainages and associated uplands. | Not expected to occur due to lack of suitable aquatic habitat. |
| San Francisco garter snake<br>*Thamnophis sirtalis tetrataenia* | FE, SE | Freshwater marshes, ponds, and slow-moving streams in San Mateo County and extreme northern Santa Cruz County; prefers dense cover and water depths of at least 1 foot. | Not expected to occur due to lack of suitable aquatic habitat. Project area is outside of known range. |
| California black rail<br>*Laterallus jamaicensis* coturniculus | ST | Salt marshes bordering larger bays, also found in brackish and freshwater marshes. | Not expected to occur due to lack of suitable marsh habitat. |
| Olive-sided flycatcher<br>*Contopus cooperi* | CSC | Edges, openings, and natural and human-created clearings in otherwise dense forests. Cup nests constructed on the upper surface of conifer, willow, alder, oak, and/or eucalyptus branches. | Known to occur. Singing individual detected near lower East Bowl Corridor during LSA site visits; occurs every year but successful breeding appears to be constrained by common raven predation (J. Clark, pers. comm.) |

| Species | Status | Habitat, Blooming Season, and Elevation | Potential for Occurrence in the Project Area |
|---|---|---|---|
| Bank swallow<br>*Riparia riparia* | SE | Vertical banks or cliffs with fine-textured or sandy soils near streams, rivers, lakes, or ocean; colonial nester. | Migrating individuals may rarely fly over but otherwise not expected to occur due to lack of suitable habitat. |
| Salt marsh common yellowthroat<br>*Geothylpis trichas sinuosa* | CSC | Salt, brackish, and freshwater marshes; and riparian woodlands; nests on or near ground in low vegetation | Not expected to occur due to lack of suitable marsh habitat. |
| Western red bat<br>*Lasiurus blossevillii* | CSC | Roosts primarily in foliage of trees and shrubs. Day roosts commonly in edge habitats adjacent to streams or open fields. | Migratory individuals may occasionally roost in trees in Reserve for brief periods. |
| American badger<br>*Taxidea taxus* | CSC | Open, dry habitats (e.g., grasslands) with friable soils. | Not expected to occur due to lack of suitable open habitat. |

Status
FE = federally listed as endangered
FT = federally listed as threatened
SE = State-listed as endangered
ST = State-listed as threatened
CSC = California Species of Special Concern
CFP = California Fully Protected Species
1B = California Rare Plant Rank 1B: species considered rare or endangered in California and elsewhere
2 = California Rare Plant Rank 2 – rare, threatened or endangered in California, but more common elsewhere.
CEQA = considered rare under Section 15380 of CEQA

### 3.3.2 Animals

The CNDDB contains records for 12 special-status animal species in the site vicinity (Table A). In addition, LSA detected a 13th species, olive-sided flycatcher, during the site visits. With the exception of monarch butterfly (*Danaus plexippus*), western red bat (*Lasiurus blossevillii*), and olive-sided flycatcher, none of these species are expected to occur due to a lack of suitable habitat. All three of the federally endangered butterfly species (San Bruno elfin butterfly [*Callophrys mossii bayensis*], Mission blue butterfly [*Plebejus icarioides missionensis*], and callippe silverspot butterfly [*Speyeria callippe callippe*]) are highly specialized in their habitat requirements, and are restricted in the San Francisco peninsula to native scrub and grassland communities on San Bruno Mountain and vicinity. In addition, the larval food plants of these species are absent from the Reserve. The absence of ponds, perennial streams, or freshwater marsh on the Reserve precludes the occurrence of California red-legged frog (*Rana draytonii*), western pond turtle (*Actinemys marmorata*), and San Francisco garter snake (*Thamnophis sirtalis tetrataenia*). California black rail (*Laterallus jamaicensis coturniculus*) is restricted to tidal salt marshes surrounding San Francisco Bay, and is thus absent from the immediate site vicinity. Similarly, the lack of freshwater or brackish marsh precludes the occurrence of salt marsh common yellowthroat (*Geothylpis trichas sinuosa*). Migratory bank swallows (*Riparia riparia*) may rarely forage over the summit clearing during the spring and fall but are not expected to use the Reserve for extensive foraging or nesting. American badger (*Taxidea taxus*) has not been observed in San Francisco since the late 1940s (CDFG 2010) and the Reserve lacks extensive open grassland in which this species typically occurs. The remaining species that are known to or may occasionally occur on the Reserve are briefly discussed below.

**Monarch Butterfly.** Although monarch butterflies have no special status under the California Fish and Game Code, overwintering aggregations along the central California coast are considered sensitive by CDFG and impacts to known aggregation sites are typically considered significant under CEQA. Overwintering monarch aggregations typically form in groves of eucalyptus or Monterey pine

along the coast by late October and usually break up in late February (Shapiro 2007). Winter aggregations vary in size from 100 to many thousands of butterflies, which form clusters usually located between 20 and 60 feet (or higher) aboveground. Clusters within eucalyptus groves are often located within openings that allow sunlight to warm the aggregating butterflies.

The CNDDB contains seven records for wintering monarch roosts in San Francisco, with the most recent occurring in the Presidio (east of Washington Boulevard and north of Compton Road) in 1998 (CDFG 2010). Although no wintering monarch roosts have been observed in the Reserve to date (P. Brastow, pers. comm.), the dense eucalyptus forest provides suitable habitat for such roosts, particularly on the northern and eastern slopes that are sheltered from the prevailing westerly winds.

**Olive-sided Flycatcher.** Olive-sided flycatcher is a California Species of Special Concern. It is typically associated with late-successional forests with open canopies in mountainous portions of the state, but has expanded locally in lowlands of the San Francisco Bay region to occupy plantings of conifers and eucalyptus (Shuford 1993). Edges and openings within otherwise dense forests are its preferred habitat as such areas provide unobstructed airspace in which to forage for insects. Snags that protrude above the surrounding canopy are an important habitat component as they provide perches for singing and foraging (Altman and Sallabanks 2000). Open-cup nests are constructed on the upper surface of a horizontal branch 5 to 70 feet up, well away from the trunk, in a cluster of live needles and twigs (Baicich and Harrison 1997).

Olive-sided flycatcher was confirmed as breeding during the San Francisco Breeding Bird Atlas effort in 1991 and 1992 (SFFO 2003). LSA detected a single singing individual near the bottom of the East Bowl Corridor below Medical Center Way during site visits on July 12 and 27. On July 27, the bird was heard singing in the Monterey cypress trees immediately adjacent to the southern side of the Woods parking lot. This species is a regular summer resident on the Reserve but its breeding success is severely constrained by common raven predation (J. Clark, pers. comm.). Given its preference for edge habitats, it is more likely to occur on the periphery of the Reserve and in larger openings within the forest than within dense portions of the forest with a closed canopy and limited sunlight penetration.

**Western Red Bat.** Western red bat (*Lasiurus blossevillii*) is a California Species of Special Concern. It is widespread in California and is typically solitary, roosting in the foliage of trees or shrubs (Bolster 1998). Day roosts are commonly in edge habitats adjacent to streams or open fields, in orchards, or sometimes in urban areas (Bolster 1998). In California, it is most commonly encountered in August and September when migrating (Jameson and Peeters 2004). The CNDDB has one record of this species in San Francisco, where a single individual was seen roosting in Strybing Arboretum in Golden Gate Park on March 12, 2000 (CDFG 2010). Migratory individuals of this species may occasionally roost in trees within the Reserve, although detection of such individuals would be extremely difficult, if not impossible. The trees around the edge of the Rotary Native Plant Garden likely provide the most suitable roosting habitat for this species, given its propensity for edge habitats.

## 3.4 SENSITIVE HABITATS

No wetlands potentially subject to Corps and/or RWQCB jurisdiction were identified during LSA's site visits. The steep topography over most of the site prevents the establishment of ponded depressions, seasonal wetlands, or other features that retain water long enough to support hydric soils

and hydrophytic vegetation (e.g., cattails). The East Bowl Corridor contains a channel that may be subject to Corps jurisdiction as other waters of the U.S. Although the channel did not contain any water during LSA's site visits, it likely conveys storm flows to the City's storm water system during the rainy season and could thus be considered an intermittent stream. Since most, if not all, of the City's storm drains eventually lead to San Francisco Bay, the Corps could exert jurisdiction over discharges of fill material below the ordinary high water mark of the intermittent stream since it is tributary to navigable waters of the U.S. The intermittent stream may also be subject to CDFG jurisdiction requiring a Streambed Alteration Agreement for ground disturbing activities under Section 1602 of the California Fish and Game Code (M. Grefsrud, pers. comm.). The project description does not call for discharge of any fill material into Waters of the U.S., and activities within CDFG jurisdiction below the top of bank would be limited to removal of non-native vegetation and planting of native vegetation which would not likely be considered a streambed alteration. In addition, the BMP's incorporated into the project description would avoid sedimentation and other adverse affects to the channel, so that impacts would be minimal and no permits would be required.

# 4.0 POTENTIAL IMPACTS AND RECOMMENDED MITIGATION MEASURES

This section analyzes potential impacts to biological resources that may result from implementation of the proposed project. The following discussion analyzes potential impacts to biological resources for each of the six significance criteria defined on the San Francisco CEQA Checklist. The project would have a significant impact on biological resources if a finding of *significant (S)* were applied to any of the San Francisco CEQA Checklist questions (in italics) below. Impacts considered *less-than-significant* before or after mitigation are designated by *LS*.

*Would the project have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?*

**Impact 1. The proposed project could remove trees that support overwintering aggregations of monarch butterflies.** As mentioned above, the dense eucalyptus forest provides suitable roosting conditions for wintering monarch butterflies. Removal of any trees supporting such roosts during the wintering season (October-February) would be considered a significant impact. Implementation of the following mitigation measure would reduce this impact to a *less-than-significant* level.

> **Mitigation Measure 1.** Prior to treatment, if conducted in the wintering season (October-February), a qualified biologist familiar with monarch butterfly aggregating behavior and habitat shall conduct a survey of all treatment areas for the presence of overwintering monarch butterfly aggregations. The survey shall be conducted in December or January since aggregations are well-established by then. If any trees are identified as supporting monarch butterfly aggregations, such trees shall be clearly marked in the field and on project plans so that the tree(s) can be avoided with a 200-foot buffer during tree removal operations until the aggregation has dispersed. (*LS*)

**Less than Significant Impacts.** The proposed tree removals could impact roosting bats, if present within the Reserve. Individual western red bats potentially roosting on the Reserve during its August-September migratory period are unlikely to be substantially affected by tree removals since the majority of existing trees on the Reserve will be retained. Individuals potentially roosting in the foliage of trees to be removed would be temporarily disturbed by removal activities, but would be able to fly away and seek alternative roost sites nearby. It is highly unlikely that tree removals would result in western red bat mortality. As such, potential project impacts on western red bats are considered *less than significant*. Impacts to maternity colonies of common bat species, on the other hand, would be considered significant and are discussed below under Impact 4.

The project is not expected to impact nesting olive-sided flycatchers (California Species of Special Concern) if tree removals are conducted outside the nesting season of February 15–August 15. Implementation of mitigation measure 3 (see below) will ensure that potential impacts to this species, though unlikely, are avoided.

**Impact 2. The proposed project could impact coastal triquetrella.** Coastal triquetrella is a moss with a California Rare Plant Rank of 1B and is known from fewer than ten small coastal occurrences, including one within 0.1 mile of the project area. If access or staging areas could substantially disturb suitable habitat on open gravel sites that was occupied by this species, it would be considered a significant impact. Implementation of the following mitigation measure would reduce this impact to a *less-than-significant* level.

> **Mitigation Measure 2.** Prior to project implementation, a qualified biologist familiar with identification of this moss shall conduct a survey of all treatment access or staging areas in suitable open gravel habitat for the presence of coastal triquetrella. The survey could be conducted any time of the year because this moss is identifiable from vegetative characteristics. If coastal triquetrella is identified as occurring in areas that would be subject to ground disturbance, the occurrence(s) shall be clearly marked in the field and on project plans so that they can be avoided during treatment operations. (*LS*)

*Would the project have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFG or USFWS?*

No riparian habitat or other sensitive natural communities are present on the site. However, the intermittent stream on the eastern side of the Reserve (i.e., East Bowl Corridor) may be subject to CDFG jurisdiction under Section 1602 of the California Fish and Game Code. UCSF should contact CDFG prior to project implementation to determine whether a Lake or Streambed Alteration Agreement (LSAA) is necessary for proposed activities in the East Bowl Corridor. Even if an LSAA is required, however, the project is not expected to have a substantial adverse effect on the stream since proposed activities in the East Bowl Corridor are intended to re-establish a native riparian plant community dominated by coast redwood, California bay, and willows. Short-term impacts associated with construction-related disturbance would be avoided by the BMP's incorporated into the project description, and result in long-term benefits associated with increased wildlife habitat value and native plant diversity due to the proposed restoration. Impacts would therefore be *less-than-significant.*

*Would the project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?*

The intermittent channel in East Bowl Corridor could be considered a jurisdictional wetland if it supports wetland vegetation. Even if not, the area of the channel below the ordinary high water mark would likely be jurisdictional as "Other Waters of the U.S." The project description does not propose the discharge of any fill material into the channel, and the BMP's incorporated into the project description would avoid sedimentation or other forms of pollution. Impacts would therefore be *less-than-significant.*

*Would the project interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?*

The term "corridor" as applied to wildlife habitat and movement has been defined in a variety of ways by ecologists, wildlife biologists, and landscape planners. For the purposes of this report, a corridor is defined as "any space, usually linear in shape that improves the ability of organisms to move among patches of their habitat" (Hilty et al. 2006). In the San Francisco Bay Area, landscape elements that facilitate local and/or regional wildlife movement include stream drainages, canyons, ridges, or other prominent natural or man-made landscape features. Corridors in highly modified landscapes can be beneficial for such generalist species adapted to human disturbance, but may not serve habitat specialists (Hilty et al. 2006). Using the above definition, the Mount Sutro Open Space Reserve does not constitute a wildlife corridor because it does not facilitate wildlife movement through the urban landscape of San Francisco. While it provides habitat for many urban-adapted wildlife species, it is isolated from other patches of similar habitat due to the dense urban development in the intervening space. Moreover, species that use and move through the Reserve (e.g., northern raccoon) are opportunistic generalists that are equally adept at moving through both high-density residential neighborhoods and undeveloped open space areas. The relatively limited amount of vegetation removal that will occur within the Reserve will also not interfere substantially with the movement of existing wildlife through the Reserve, and therefore impacts on these wildlife species would be *less than significant*.

**Impact 3. Proposed tree thinning and other vegetation removal could impact active bird nests.** Most, if not all, of the proposed tree thinning and vegetation removal work is proposed to be conducted outside the nesting season for most bird species (February 15–August 15). However, early-nesting species such as great horned owl and Anna's hummingbird could potentially be impacted by such activities. Due to the unpredictability of project and contractor scheduling, there is also some potential that vegetation removal may have to be conducted during the primary nesting season. Such activities could directly impact nesting birds by removing trees or shrubs that support active nests. Construction-related disturbance (e.g., noise, vehicle traffic, personnel working adjacent to suitable nesting habitat) could also indirectly impact nesting birds by causing adults to abandon nests in nearby trees or other vegetation, resulting in nest failure and reduced reproductive potential. As described above in Sections 1.4.3 and 1.4.6 nests of native birds are protected under the federal Migratory Bird Treaty Act and California Fish and Game Code. Implementation of the following mitigation measures would reduce this impact to a *less-than-significant* level.

> **Mitigation Measure 3a.** While it is anticipated that the proposed tree thinning and vegetation removal activities would be scheduled outside of the nesting season, this may not always be feasible. Prior to any tree thinning and vegetation removal activities that would occur between December 15 (for early-nesting species) and August 15, a qualified biologist shall conduct a preconstruction nest survey of all suitable nesting habitat on and within 50 feet of the limits of work. The survey shall be conducted no more than 15 days prior to the start of work at a given project area. The applicant and/or contractor shall clearly delineate the trees and other vegetation proposed for removal to ensure that the biologist surveys the work area as thoroughly as possible. If the survey indicates the presence of nesting birds, the biologist shall determine an appropriately sized buffer around the nest in which no work would be allowed until the young have successfully fledged or the nest has failed. The size of the nest buffer shall be determined by the biologist and shall be based on the nesting species and its sensitivity to disturbance. In general, buffer sizes of up to 250 feet for raptors and 50 feet for other birds should suffice to prevent substantial disturbance to nesting birds, but these buffers

may be increased or decreased, as appropriate, depending on the bird species, site conditions and the level of disturbance anticipated near the nest. (LS)

**Mitigation Measure 3b.** Prior to identifying trees for removal, a qualified biologist familiar with raptor nesting habitat shall examine the treatment area for mature trees that should be retained to provide raptor nesting habitat. Dead snags that provide habitat for woodpeckers and other cavity-nesting species should also be retained to the degree practicable. Trees and/or snags recommended for retention should be clearly marked both in the field and on project plans so they are not inadvertently cut down during tree thinning and understory removal activities. (*LS*)

**Impact 4. Proposed tree thinning and other vegetation removal could impact bat maternity colonies.** Large, deep cavities in trees within the Reserve could potentially support maternity colonies of common bat species such as big brown bat or Brazilian free-tailed bat. None of the trees proposed to be removed would be large enough to support cavities suitable for bat roosting, so there is no potential that bat maternity colonies could be impacted. Individual tree roosting bats would likely not be impacted by tree removal due to the large amount of suitable roosting habitat that will be protected on the project site. Individual bats roosting in trees during tree removal will likely fly away and seek alternative roost sites when disturbed. Impacts to bats from tree removal would therefore be *less-than-significant.*

*Would the project conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?*

**Impact 5.** A full inventory of the existing trees within treatment areas has not yet been conducted. Several trees within the project area would qualify for protected status under the San Francisco Urban Forestry Ordinance if they were on privately owned land. Protected trees include the following:

- Landmark Trees – UCSF has none at its Parnassus Heights Campus, including the Mt. Sutro Open Space Reserve.
- Significant Trees – trees within 10 feet of property line that are taller than 20 feet or with a canopy greater than 15 feet or with a trunk greater than 12" at breast height. Individual trees meeting these criteria that pose a hazard to life or property may need to be removed for this project.
- Street Trees – no street trees would be removed as part of this project.

As noted previously, the Reserve is designated by the Regents as permanent open space and is open to the public, not only for UCSF but for the greater community. The Reserve is not privately owned and UCSF would not be subject to this Ordinance. The proposal is to implement vegetation management activities to restore and enhance the Reserve, in consultation with qualified arborists and urban forestry professionals. By implementing Mitigation Measure 3a and 3b, any potential impact to nesting birds due to the proposed tree thinning and removal would be reduced to a less-than-significant level. In addition, UCSF has conducted substantial public outreach regarding the proposed project, and would continue to do so, which would provide a suitable substitute for the public notice requirements of the Urban Forestry Ordinance (DPW Code Article 16). Accordingly, the proposed project would not conflict with any local policies or ordinances protecting biological resources and impacts would be *less than significant*.

*Would the project conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or State habitat conservation plan?*

The Reserve is not located within any lands subject a to local, regional, or State habitat conservation plan.

# 5.0 REFERENCES

Altman, B. and R. Sallabanks. 2000. Olive-sided Flycatcher (*Contopus cooperi*), *in* A. Poole and F. Gill, editors. The Birds of North America, no. 502. Birds of North America, Philadelphia, Pennsylvania.

American Ornithologists' Union (AOU). 1998. Check-list of North American birds. Seventh edition. American Ornithologists' Union, Washington, D.C.

Baicich, P.J. and C.J.O. Harrison. 1997. Nests, eggs, and nestlings of North American birds. Second edition. Academic Press, San Diego, California.

Baker, R.J., L.C. Bradley, R.D. Bradley, J.W. Dragoo, M.D. Engstrom, R.S. Hoffmann, C.A. Jones, F. Reid, D.W. Rice, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. Museum of Texas Tech University Occasional Papers 229.

Beidleman, L.H. and E.N. Kozloff. 2003. Plants of the San Francisco Bay Region (Revised Edition). University of California Press, Berkeley.

Bolster, B. 1998. Western Bat Working Group (WBWG) species account for western red bat. Developed for the 1998 Reno Biennial Meeting, updated at the 2005 Portland Biennial Meeting. http://www.wbwg.org/speciesinfo/species_accounts/vespertilonidae/labl.pdf Accessed 6/10.

Brodo, I.M., S.D. Sharnoff and, S. Sharnoff. 2001. Lichens of North America. Yale University Press, New Haven, Connecticut.

California Department of Fish and Game. 2010. California Natural Diversity Database (CNDDB), commercial version dated July 3, 2010. Biogeographic Data Branch, California Department of Fish and Game, Sacramento.

California Invasive Plant Council (Cal-IPC). 2006. California Invasive Plant Inventory. Cal-IPC Publication 2001-6. California Invasive Plant Council, Berkeley. http://www.cal-ipc.org/ip/inventory/weedlist.php Accessed 6/10

California Native Plant Society (CNPS). 2010. Inventory of rare and endangered plants of California (online edition, v7-10b). California Native Plant Society, Sacramento. http://www.cnps.org/inventory Accessed 6/10

Consortium of California Herbaria (Consortium), 2010 database is provided by the participants of the Consortium of California Herbaria. <ucjeps.berkeley.edu/consortium> Accessed 6/10

Crother, B.I., editor. 2008. Scientific and standard English names of amphibians and reptiles of North America north of Mexico. Society for the Study of Amphibians and Reptiles (SSAR) Herpetological Circular 37.

Doyle, W.T. and R.E. Stotler. 2006. Contributions toward a Bryoflora of California: III. Keys and Annotated Species Catalogue for Liverworts and Hornworts. Madroño 53(2):89–197.

EDAW, Inc. 2001. Mount Sutro Open Space Reserve Management Plan. Prepared for the University of California, San Francisco with assistance from Ralph Osterling Consultants, Inc., San Mateo, California.

Esslinger, T.L. 2010. A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. North Dakota State University, Fargo. <http://www.ndsu.nodak.edu/instruct/esslinge/chcklst/chcklst7.htm> (first posted 1 December 1997, most recent version [#16] 18 June 2010).

Hickman, J.C., editor. 1993. The Jepson manual: higher plants of California. Third printing with corrections, 1996. University of California Press, Berkeley.

Hilty, J.A., W.J. Lidicker, Jr., and A.M. Merenlender. 2006. Corridor ecology: The science and practice of linking landscapes for biodiversity conservation. Island Press, Washington, D.C.

Jameson, E.W., Jr., and H.J. Peeters. 2004. Mammals of California (revised edition). University of California Press, Berkeley.

Jennings, M.R. and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. Final report to California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova.

Interagency Special Status/Sensitive Species Program (ISSSSP). 2007. Species Fact Sheet, *Triquetrella californica*, prepared by John A. Christy. Interagency – Oregon/Washington State, DOI Bureau of Land Management/USDA Forest Service. http://www.fs.fed.us/r6/sfpnw/issssp Accessed 6/10

Moyle, P.B., R.N. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California. Second edition. Prepared for California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova. Final report for Contract No. 2128IF. June.

Norris, D.H. and J.R. Shevock. 2004a. Contributions toward a Bryoflora of California: I. A Specimen-Based Catalogue of the Mosses. Madroño 51(1):1–131.

———. 2004b. Contributions toward a Bryoflora of California: II. A Key to the Mosses. Madroño 51(2):1–131.

San Francisco Field Ornithologists (SFFO). 2003. Draft San Francisco Breeding Bird Atlas.

Sawyer, J.O., T. Keeler-Wolf, and J.M. Evens. 2009. A Manual of California Vegetation. Second edition. California Native Plant Society Press, Sacramento.

Shapiro, A.M. 2007. Field guide to butterflies of the San Francisco Bay and Sacramento Valley regions. University of California Press, Berkeley and Los Angeles.

Shuford, W.D. 1993. The Marin County breeding bird atlas: A distributional and natural history of coastal California birds. Bushtit Books, Bolinas, California.

Shuford, W.D. and T. Gardali, editors. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

Williams, D.F. 1986. Mammalian Species of Special Concern in California. California Department of Fish and Game, Sacramento.

## Personal Communications

Brastow, Peter. Nature in the City. September 9, 2010.

Clark, Josiah. Habitat Potential. September 15, 2010.

Grefsrud, Marcia. California Department of Fish and Game. August 23, 2010.

Sigg, Jake. Mount Sutro Stewards. July 12, 2010, and January 20, 2011.

# APPENDIX A

# PLANT AND ANIMAL SPECIES LISTS

# ANIMAL SPECIES OBSERVED ON THE MOUNT SUTRO OPEN SPACE RESERVE, UNIVERSITY OF CALIFORNIA – SAN FRANCISCO

LSA biologists observed or detected the sign (e.g., tracks, scat, nests, burrows etc.) of the following vertebrate animal (wildlife) species on the Mount Sutro Open Space Reserve on July 12 and 27, 2010.

| Common Name | Scientific Name | Seasonal Occurrence/Nesting Status |
|---|---|---|
| **Birds** | | |
| Red-shouldered hawk | *Buteo lineatus* | R |
| Red-tailed hawk | *Buteo jamaicensis* | R |
| White-throated swift | *Aeronautes saxatalis* | FO |
| Anna's hummingbird | *Calypte anna* | R |
| Allen's hummingbird | *Selasphorus sasin* | S |
| Downy woodpecker | *Picoides pubescens* | R |
| Northern flicker | *Colaptes auratus* | R |
| Olive-sided flycatcher | *Contopus cooperi* | S |
| Pacific-slope flycatcher | *Empidonax difficilis* | S |
| Steller's jay | *Cyanocitta stelleri* | R |
| Common raven | *Corvus corax* | R |
| Chestnut-backed chickadee | *Poecile rufescens* | R |
| Bushtit | *Psaltriparus minimus* | R |
| Brown creeper | *Certhia americana* | R |
| Pygmy nuthatch | *Sitta pygmaea* | R |
| Pacific wren | *Troglodytes pacificus* | R/N |
| American robin | *Turdus migratorius* | R |
| Orange-crowned warbler | *Oreothlypis celata* | R |
| Wilson's warbler | *Wilsonia pusilla* | S |
| California towhee | *Melozone crissalis* | R |
| Song sparrow | *Melospiza melodia* | R/N |
| Dark-eyed junco | *Junco hyemalis* | R/N |
| Purple finch | *Carpodacus purpureus* | R |
| House finch | *Carpodacus mexicanus* | R |
| American goldfinch | *Spinus tristis* | R |
| Lesser goldfinch | *Spinus psaltria* | R |
| **Mammals** | | |
| Eastern gray squirrel* | *Sciurus carolinensis* | R |

R = Year-round resident: expected to breed in the project area or in the vicinity.
S = Spring/summer resident: may nest in the project area or in the vicinity.
FO = Flyover
N = evidence of nesting observed (e.g., fledglings, adults carrying food or nesting material)
* = Non-native species

# PLANT SPECIES OBSERVED ON THE MOUNT SUTRO OPEN SPACE RESERVE, UNIVERSITY OF CALIFORNIA – SAN FRANCISCO

The following is a list of 151 plant vascular species observed on Mt. Sutro during the years 1993 to 2010 by the Mount Sutro Stewards, and those made by LSA's botanist in 2010. The observed flora is composed of 57 plant families, and includes 87 native species (58%) and 64 non-native species (42%).

| **Scientific Name** | **Common Name** | **Native Status** |
|---|---|---|
| ANACARDIACEAE | SUMAC/CASHEW FAMILY | |
| *Toxicodendron diversilobum* | Poison oak | yes |
| | | |
| APIACEAE | CARROT FAMILY | |
| *Angelica hendersonii* | Angelica | yes |
| *Conium maculatum* | Poison hemlock | no |
| *Heracleum lanatum* | Cow parsnip | yes |
| *Osmorhiza chilensis* | Sweet cicely | yes |
| *Sanicula crassicaulis* | Wood sanicle | yes |
| *Torilis arvensis* | Torilis | no |
| | | |
| APOCYNACEAE | DOGBANE FAMILY | |
| *Vinca major* | Periwinkle | no |
| | | |
| ARACEAE | ARUM FAMILY | |
| *Arum italicum* | Italian loards and ladies | no |
| | | |
| ARALIACEAE | GINSENG FAMILY | |
| *Hedera helix* | English ivy | no |
| | | |
| ARISTOLOCHIACEAE | PIPEVINE FAMILY | |
| *Aristolochia californica* | Pipevine | yes |
| | | |
| ASTERACEAE | SUNFLOWER FAMILY | |
| *Achillea millefolium* | Yarrow | yes |
| *Anaphalis margaritaceae* | Pearly everlasting | yes |
| *Artemisia californica* | California sagebrush | yes |
| *Artemisia douglasiana* | Mugwort | yes |
| *Baccharis pilularis* | Coyote brush | yes |
| *Bellis perennis* | English daisy | no |
| *Carduus pycnocephalus* | Italian thistle | no |
| *Cirsium brevistylum* | Indian thistle | yes |
| *Delairea oderata* | German ivy | no |
| *Erechtites glomerata* | Australian fireweed | no |
| *Erigeron glaucus* | Seaside daisy | yes |

| Scientific Name | Common Name | Native Status |
|---|---|---|
| *Eriophyllum staechadifolium* | Lizard tail | yes |
| *Grindelia hirsutula* var. *maritima* | San Francisco gumplant | yes |
| *Hieracium albiflorum* | Hawkweed | yes |
| *Pericallis hybrida* | Cineraria | no |
| *Picris echioides* | Bristly ox-tongue | no |
| *Pseudognaphalium leuteoalbum* | Jersey cudweed | no |
| *Scenecio elegans* | Purple ragwort | no |
| *Scenecio jacobea* | Tansy ragwort | no |
| *Sonchus asper* | Sow thistle | no |
| *Sonchus oleraceus* | Sow thistle | no |
| *Taraxiacum officinale* | Dandelion | no |
| | | |
| AQUIFOLIACEAE | HOLLY FAMILY | |
| *Ilix aquifolium* | Holly | no |
| | | |
| BERBERIDACEAE | BARBERRY FAMILY | |
| *Berberis pinnata* | Barberry | yes |
| | | |
| BORAGINACEAE | BORAGE FAMILY | |
| *Myosotis sylvatica* | Forget-me-not | no |
| | | |
| BRASSICACEAE | MUSTARD FAMILY | |
| *Brassica nigra* | Black mustard | no |
| *Barbarea orthoceras* | Wintercress | |
| *Cardamine californica* ssp. *integrifolia* | Milkmaids | yes |
| *Cardamine oligosperma* | Bittercress | yes |
| | | |
| CAPRIFOLIACEAE | HONEYSUCKLE FAMILY | |
| *Lonicera hispidula* var. *vacillans* | California honeysuckle | yes |
| *Lonicera involucrata* var. *ledebourii* | Twinberry | yes |
| *Sambucus racemosa* | Red elderberry | yes |
| *Symphoricarpos albus* var. *laevigatus* | Snowberry | yes |
| | | |
| CARYOPHYLLACEAE | PINK FAMILY | |
| *Stellaria media* | Chickweed | no |
| | | |
| CASUARINACEAE | BEEFWOOD FAMILY | |
| *Casuarina stricta* | Coast beefwood | no |
| | | |
| COMMELINACEAE | SPIDERWORT FAMILY | |
| *Tradescantia fluminensis* | Small-leaf spiderwort | no |
| | | |
| CONVOLVULACEAE | MORNING GLORY FAMILY | |
| *Calystegia purpurata* | Morning glory | yes |

| Scientific Name | Common Name | Native Status |
|---|---|---|
| | | |
| CUCURBITACEAE | GOURD FAMILY | |
| *Marah fabaceus* | Wild cucumber | yes |
| | | |
| CUPRESSACEAE | CYPRESS FAMILY | |
| *Callitropsis macrocarpa* | Monterey cypress | yes |
| | | |
| CYPERACEAE | SEDGE FAMILY | |
| *Carex brevicaulis* | Rock sedge | yes |
| *Carex subbracteata* | Sedge | yes |
| | | |
| DENNSTAEDTIACEAE | BRACKEN FAMILY | |
| *Pteridium aquilinum* var. *pubescens* | Bracken fern | yes |
| | | |
| DRYOPTERACEAE | WOOD FERN FAMILY | |
| *Dryopteris arguta* | Wood fern | yes |
| *Polystichum munitum* | Sword fern | yes |
| | | |
| ERICACEAE | HEATH FAMILY | |
| *Arbutus menziesii* | Pacific madrone | yes |
| *Arctostaphylos sp.* | Manzanita | yes |
| | | |
| FABACEAE | LEGUME FAMILY | |
| *Acacia decurrens* | Green wattle | no |
| *Acacia melanoxylon* | Blackwood acacia | no |
| *Genista monspessulanus* | French broom | no |
| *Lathyrus vestitus* var. *vestitus* | Hillside pea | yes |
| *Lupinus arboreus* | Yellow bush lupine | yes |
| *Vicia americana* ssp. *americana* | Vetch | yes |
| | | |
| FAGACEAE | OAK FAMILY | |
| *Quesrcus agrifolia* | Coast live oak | yes |
| | | |
| GERANIACEAE | GERANIUM FAMILY | |
| *Geranium pretense* | Meadow geranium | no |
| *Geranium robertianum* | Red robert | no |
| | | |
| GROSSULARIACEAE | GOOSEBERRY FAMILY | |
| *Ribes sanguineum* var. *glutinosum* | Pink currant | yes |
| | | |
| HIPPOCASTANANCEA | BUCKEYE FAMILY | |
| *Aesculus californica* | California buckeye | yes |
| | | |

| Scientific Name | Common Name | Native Status |
|---|---|---|
| HYDROPHYLLACEAE | WATERLEAF FAMILY | |
| *Phacelia malvifolia* | Stinging phacelia | yes |
| | | |
| IRIDACEAE | IRIS FAMILY | |
| *Iris douglasiana* | Douglas iris | yes |
| *Sisyrinchium bellum* | Blue-eyed grass | yes |
| | | |
| JUNCACEAE | RUSH FAMILY | |
| *Juncus bufonius* | Toad rush | yes |
| *Juncus patens* | Blue rush | yes |
| *Luzula comosa* | Wood rush | yes |
| | | |
| LAMIACEAE | MINT FAMILY | |
| *Salvia spathacea* | Hummingbird sage | yes |
| *Stachys ajugoides* var. *rigida* | Wood mint | yes |
| | | |
| LAURACEAE | LAUREL FAMILY | |
| *Umbellularia californica* | California bay laurel | yes |
| | | |
| LILIACEAE | LILY FAMILY | |
| *Allium triquetrum* | Wild onion | no |
| *Chlorogalum pomeridianum* var. *divaricatum* | Soap plant | yes |
| *Prosartes hookeri* | Fairy bells | yes |
| *Smilacina stellata* | Slim Solomon | yes |
| *Tritelia laxa* | Ithuriel's spear | yes |
| | | |
| MALVACEAE | MALLOW FAMILY | |
| *Lavatera assurgentifolia* | Tree mallow | no |
| *Malva nicaeenis* | Bull mallow | no |
| | | |
| MYOPORACEAE | MYOPORUM FAMILY | |
| *Myoporum laetum* | New Zealand myoporum | no |
| | | |
| MYRICACEAE | WAXMYRTLE FAMILY | |
| *Morella californica* | Pacific waxmyrtle | yes |
| | | |
| MYRTACEAE | MYRTLE FAMILY | |
| *Eucalyptus globulus* | Blue gum eucalyptus | no |
| | | |
| ONAGRACEAE | EVENING PRIMROSE FAMILY | |
| *Epilobium brachycarpum* | Willowherb | yes |
| *Epilobium ciliatum* | Willowherb | yes |
| *Fuchsia hybrida* | Hybrid fuchsia | no |
| | | |

| Scientific Name | Common Name | Native Status |
|---|---|---|
| OXALIDACEAE | OXALIS FAMILY | |
| *Oxalis albicans* ssp. *pilosa* | Wood oxalis | yes |
| *Oxalis incarnatum* | Oxalis | no |
| *Oxalis pes-carpe* | Bermuda buttercup | no |
| | | |
| PAPAVERACEAE | POPPY FAMILY | |
| *Dicentra formosa* | Bleeding heart | yes |
| *Eschscholzia californica* | California poppy | yes |
| *Fumaria officinalis* | Fumitory | no |
| | | |
| PINACEAE | PINE FAMILY | |
| *Pinus radiata* | Monterey pine | yes |
| | | |
| PLANTAGINACEAE | PLANTIAN FAMILY | |
| *Plantago lanceolata* | English plantain | no |
| *Plantago major* | Common plantain | no |
| | | |
| POACEAE | GRASS FAMILY | |
| *Briza maxima* | Rattlesnake grass | no |
| *Bromus carinatus* | California brome | yes |
| *Bromus diandrus* | Ripgut brome | no |
| *Bromus stamineus* | Harlan brome | no |
| *Calamagrostis nutkaensis* | Nootka reed grass | yes |
| *Cynosurus echinatus* | Dogtail grass | no |
| *Dactylus glomerata* | Orchard grass | no |
| *Ehrharta erecta* | Veldt grass | no |
| *Elymus glaucus* | Wild rye | yes |
| *Festuca rubra* | Red fescue | no |
| *Holcus lanatus* | Velvet grass | no |
| *Hordeum murinum* | Hare barley | no |
| *Melica torreyana* | Melic grass | yes |
| *Poa annua* | Annual bluegrass | no |
| | | |
| POLYGONACAE | BUCKWHEAT FAMILY | |
| *Rumex acetosella* | Sheep sorrel | no |
| *Rumex conglomeratus* | Green dock | no |
| *Rumex crispus* | Curly dock | no |
| | | |
| POLYPODIACEAE | POLYPODY FAMILY | |
| *Polypodium californicum* | California polypody | yes |
| *Polypodium scouleri* | Leather fern | yes |
| | | |
| PORTULACEAE | PURSLANE FAMILY | |
| *Claytonia perfoliata* | Miner's lettuce | yes |

| Scientific Name | Common Name | Native Status |
|---|---|---|
| | | |
| PTERIDACEA | BRAKE FAMILY | |
| *Pentagramma triangularis* | Gold-back fern | yes |
| | | |
| RANUNCULACEAE | BUTTERCUP FAMILY | |
| *Aquilegia formosa* | Columbine | yes |
| | | |
| RHAMNACEAE | BUCKTHORN FAMILY | |
| *Frangula californica* | California coffeberry | yes |
| *Ceanothus griseus* | Carmel ceanothus | |
| *Ceanothus thyrsiflorus* | California lilac | yes |
| | | |
| ROSACEAE | ROSE FAMILY | |
| *Cotoneaster lacteus* | Cotoneaster | no |
| *Cotoneaster pannosa* | Cotoneaster | no |
| *Fragaria vesca* | Woodland strawberry | yes |
| *Heteromeles arbutiflora* | Toyon | yes |
| *Holodiscus discolor* | Ocean spray | yes |
| *Oemleria cerasiformis* | Oso berry | yes |
| *Prunus cerasiformis* | Wild plum | no |
| *Prunus cerasiformis "atropurpurea"* | Purple-leaf plum | no |
| *Prunus ilicifolia* ssp. *lyonii* | Catalina cherry | yes |
| *Pyracantha angustifolia* | Firethorn | no |
| *Rosa californica* | California rose | yes |
| *Rosa gymnocarpa* | Wood rose | yes |
| *Rubus armeniacus* | Himalayan blackberry | yes |
| *Rubus ursinus* | California blackberry | yes |
| | | |
| RUBIACEAE | MADDER FAMILY | |
| *Galium aparine* | Cleavers | yes |
| *Coprosma repens* | Mirror plant | no |
| | | |
| SAXIFRAGACEAE | SAXIFRAGE FAMILY | |
| *Tellima grandiflora* | Fringe cups | yes |
| | | |
| SCROPHULARIACEAE | FIGWORT FAMILY | |
| *Mimulus aurantiacus* | Bush monkey flower | yes |
| *Mimulus guttatus* | Monkey flower | yes |
| *Scrophularia californica* | Bee plant | yes |
| | | |
| SOLANACEAE | NIGHTSHADE FAMILY | |
| *Salpichroa origanifolia* | Lily of the valley vine | no |
| *Solanum furcatum* | Nightshade | no |
| *Solanum laciniatum* | Kangaroo apple | no |

| Scientific Name | Common Name | Native Status |
|---|---|---|
| TAXODIACEAE | BALD CYPRESS FAMILY | |
| *Sequoia sempervirens* | Coast redwood | yes |
| | | |
| TROPAEOLACEAE | NASTURTIUM FAMILY | |
| *Tropaeolum majus* | Garden nasturtium | no |
| | | |
| VALERIANACEAE | VALERIAN FAMILY | |
| *Centranthus rubber* | Red valerian | no |

# LICHEN, BRYOPHYTE, AND FUNGI SPECIES OBSERVED ON THE MOUNT SUTRO OPEN SPACE RESERVE, UNIVERSITY OF CALIFORNIA – SAN FRANCISCO

LSA biologists observed the following 17 species of native non-vascular plants (six mosses, two liverworts, and nine lichens) and three fungi on the Mount Sutro Open Space Reserve. Common names are not provided for moss and liverwort species since they lack commonly accepted vernacular names.

| **Scientific Name** | **Common Name** |
|---|---|
| **Lichens** | |
| *Cladonia asahinae* | Pixie cup lichen |
| *Cladonia macilenta* | Cup lichen |
| *Evernia prunastri* | Oakmoss lichen |
| *Lepraria sp.* | Lepraria |
| *Parmotrema chinense* | Powdered ruffle lichen |
| *Platismatia sp.* | Rag lichen |
| *Usnea sp.* | Old man's beard |
| *Xanthoparmelia sp.* | Rock lichen |
| *Xanthoria sp.* | Orange wall lichen |
| **Mosses** | |
| *Brachythecium velutinum* | none |
| *Fissidens crispus* | none |
| *Isothecium cristatum* | none |
| *Kindbergia oregana* | none |
| *Tortella alpicola* | none |
| *Ulota megalospora* | none |
| **Liverworts** | |
| *Lophocloea bidentata* | none |
| *Scapania bolanderi* | none |
| **Fungi** | |
| *Coprinellus micaceus* | Mica cap |
| *Mycena adscendens* | Mycena |
| *Tremella aurantia* | Witch's butter |

# APPENDIX D

CULTURAL RESOURCES REPORT

**Final**

# MOUNT SUTRO OPEN SPACE RESERVE

# CULTURAL LANDSCAPE EVALUATION REPORT

**Prepared for**
**University of California San Francisco, Campus Planning**

**Prepared by**
**Denise Bradley, ASLA, and Knapp & VerPlanck Preservation Architects**

**3 October 2011**

**Revised 10 January 2013**

Photo on cover: No. 51 in Baldwin's 1910 Appraisal of Sutro's Estate. "Standing on the Knoll on Block 745 to the north of Parnassus Avenue, looking southwesterly across Parnassus Avenue towards the Sutro Forest and Affiliated Colleges" (Source: San Francisco History Center, San Francisco Public Library).

# I. EXECUTIVE SUMMARY

## A. Summary of the Project Description

The University of California, San Francisco ("UCSF") proposes to implement a number of management actions in the UCSF Mount Sutro Open Space Reserve ("Reserve"). The Reserve is a largely undeveloped 61-acre forest located within UCSF's Parnassus Heights campus site at the center of San Francisco. The Reserve, designated as permanent open space by The Regents of the University of California in 1973, is open to the public and serves as a point of respite and recreation not only for UCSF but for the greater community.

Vegetation management actions are proposed to occur throughout the Reserve over many years and would be phased beginning with four demonstration projects that were crafted with the interested public in a Community Planning Process. The first three demonstration projects are planned for implementation following the completion of environmental review and project approval. The fourth demonstration project would be implemented approximately one year after the first three. Also, a "Hands-Off" management area in which no vegetation management would be undertaken for the one-year duration of the demonstration project timeframe is proposed as requested by some community members. The demonstration projects would include a range of potential management actions that could be later implemented throughout the entire Reserve. Such actions would be first implemented in these four small areas to "demonstrate" to the public the range of potential results. Public feedback would then inform the University's choices in the management activities to be applied to the remainder of the Reserve over time. The management actions identified for the demonstration areas are proposed to be applied ultimately beyond the demonstration areas to the remainder of the Reserve, as appropriate, subject to further refinement by UCSF and its urban foresters in consultation with the interested public.

UCSF has prepared an Initial Study in accordance with the California Environmental Quality Act (CEQA) (California Public Resources Code, Sections 21000-21177) and the Guidelines for Implementation of CEQA (California Code of Regulations, Title 14, Sections 15000-15387) to provide a preliminary evaluation of the proposed project and to determine upon which environmental topics the project may have a significant adverse effect requiring further analysis in an Environmental Impact Report (EIR). Those environmental topics, identified in the *Notice of Preparation/Initial Study: University of California San Francisco, Mount Sutro Management (*"Notice of Preparation/Initial Study"*),* for which the proposed project would have a "Less than Significant Impact," "Less than Significant Impact with Project Mitigation," or "No Impact," will not be analyzed further in the EIR. Topics for which the proposed project would have "Potentially Significant" environmental impacts will be analyzed in the EIR. The Notice of Preparation/Initial Study identified environmental impacts to historical resources as "Potentially Significant" and stated that the "EIR will assess the Mount Sutro

Open Space Reserve to determine whether it qualifies as a cultural landscape (i.e. a historical resource) and whether effects of the proposed project on historical resources will be significant."

## B. Purpose of This Cultural Landscape Evaluation Report

This Cultural Landscape Evaluation Report was prepared to determine whether the Reserve qualifies as a historical resource under the California Register of Historical Resources criteria and to determine whether the proposed management activities would have a significant impact on a historic resource.

## C. Summary of the Evaluation

The Reserve appears to be eligible for listing in the California Register of Historical Resources and is therefore determined to be a historical resource for the purposes of CEQA.

The evaluation in this Cultural Landscape Evaluation Report includes the 61-acre Reserve, which comprises the major portion of the extant Mount Sutro Cultural Landscape. The Mount Sutro Cultural Landscape consists of the 61-acre Reserve that is owned and managed by UCSF and the 12-acre portion of the Interior Greenbelt that is adjacent to the east side of the Reserve. The Interior Greenbelt is owned by the City and County of San Francisco and is managed by the San Francisco Recreation and Park Department. No intensive survey was conducted of the Interior Greenbelt as part of this Cultural Landscape Evaluation Report, and an evaluation to document the existing conditions and to evaluate the integrity of the Interior Greenbelt was outside the scope of this report.

The Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 1 (Events) for its association with the history of open space in San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for the city; this period of significance extends from 1886 when Adolph Sutro first began to plant the forest to the present. Additionally, the Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 2 (Persons) for its association with Adolph Sutro and his development of the Sutro Forest; this period of significance extends from 1886 when Sutro first began to plant the Sutro Forest until his death in 1898.

The Reserve maintains its integrity related to these two areas of significance.

The character-defining features of the Reserve that convey its historical significance include (1) the presence of a forest that covers the overwhelming majority of the land area and whose dominant species is eucalyptus, (2) the presence of the Historic and Fairy Gates trails as part of a consciously laid out trail system and the presence of informal or social trails which have developed over time related to land use activities and to provide connections into Mount Sutro from the surrounding neighborhoods, and (3) the natural topographic

characteristics of the site including the steep terrain, the rock outcrops, Stanyan Canyon, and the summit.

## D. Summary of the Analysis of Impacts

### *Four Demonstration Areas and the "Hands-off" Area*

The proposed Management Plan activities related to the four demonstration areas and the "Hands-off" area were reviewed for their potential to materially impair the character-defining features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the four demonstration areas and the "Hands-off" area activities would demolish or materially alter in an adverse manner the physical characteristics—the character defining features consisting of a forest whose predominant species is eucalyptus, the trail system and the natural topographic characteristics—of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources.

The evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the activities would be limited to the four demonstration areas; (2) the demonstration areas are located within different parts of the Reserve so that the activities would not be concentrated in any one zone or part of the Reserve; (3) the total area within the demonstration areas would affect only about 7.5 acres of the total 61 acres of land within the Reserve, (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape, and (5) the Reserve would continue to exhibit its seven components of integrity (location, design, materials, workmanship, setting, feeling, and association) as described the "Evaluation" section. In summary, the proposed activities related to the four demonstration areas and "Hands-off" management area would have a less-than-significant impact on the Reserve as a historical resource.

### *Continued Implementation*

After the completion and assessment of Demonstration Project 2: Edgewood Avenue Area, management actions in Demonstration Project 2 would be selected for application to the remainder of the Edgewood Avenue Area (shown on Figure 3-4 as area "I" and including lands west of area "I' to Medical Center Way), including the planting of native trees, shrubs and other plants as understory within the existing forest whose predominant species is eucalyptus.

In addition, after the completion and assessment of the Demonstration Project 1: South Ridge Area, management actions proposed in Demonstration Project 1 would be selected for application to other areas of the Reserve, excluding the other demonstration project areas, and the Rotary Meadow at the summit.

These management actions would include the planting of native species and enhancement of existing remnant native plant communities.

Of the Reserve's 61 acres, conversion planting would occur in the East Bowl Corridor (about 2 acres) and potentially in Area "K" (about 1.5 acres). Accounting for the loss of eucalyptus-forested area due to these proposed conversion plantings and the conversion of the summit (about 1.5 acres) that has already occurred, about 56 acres of forested area would remain where the predominant species is eucalyptus. Thus, the overwhelming majority of the Reserve would remain a eucalyptus forest, although at a lower density of trees per acre than exists today.

The activities related to the continued implementation of the proposed Management Plan were reviewed for their potential to materially impair the character-defining features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the full implementation of these activities (i.e., the implementation of the Demonstration Project 2 management actions throughout the Edgewood Area, the implementation of the Demonstration Project 1 management actions throughout other areas of the Reserve [excluding the other demonstration project areas and the Rotary Meadow at the summit], and the planting of native species and enhancement of existing remnant native plant communities) would demolish or materially alter in an adverse manner the physical characteristics—the character defining features consisting of a forest whose predominant species is eucalyptus, the trail system and the natural topographic characteristics—of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources.

This evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the proposed vegetation management actions described in Section 3.5.2.: Continued Implementation, (2) the best management practices described in Section 3.5.5: Best Management Practices, (3) 56 acres of forested area where the predominant species is eucalyptus would remain, (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape, and (5) the Reserve would continue to exhibit its seven components of integrity (location, design, materials, workmanship, setting, feeling, and association) in the "Evaluation" section. In summary, the proposed activities related to the continued implementation of the proposed Management Plan would have a less-than-significant impact on the Reserve as a historical resource.

### *Trail System Improvements*

The proposed Management Plan activities related to the trail system improvements, including the addition of three new trails and new switchbacks, were reviewed for their potential to materially impair the character-defining

features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the trail system improvements would demolish or materially alter in an adverse manner the physical characteristics of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources—the character-defining features consisting of a forest whose predominant species is eucalyptus, the trail system, and the natural topographic characteristics.

The evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the trail system improvements would result in minimal vegetation removal; (2) the grading proposed would be limited to minor alterations in the topography in the vicinity of the trail improvements; (3) the existing trails and the three new proposed trails would remain unpaved and (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape. In summary, the proposed activities related to the trail system improvements would have a less-than-significant impact on the Reserve as a historical resource.

### *Ongoing Maintenance*

UCSF, with the assistance of the Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees and restoring trails. The goals and general description for ongoing maintenance are consistent with the protection of the Reserve as a historical resource. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

### *Cumulative Impacts Analysis*

The geographic context for analysis of cumulative impacts on historical resources encompasses the entire extant Mount Sutro Cultural Landscape including both the 61-acre Reserve and the 12-acre portion of the City-owned Interior Greenbelt that adjoins the east side of the Reserve and extends to Stanyan Street.

In addition to the proposed activities of the proposed project, future cumulative projects that have potential to affect the historical significance of the Mount Sutro Cultural Landscape include the City's management strategies for the Interior Greenbelt as defined in the final draft of the *Significant Natural Resource Areas Management Plan* (SNRAMP). SNRAMP activities for the Interior Greenbelt would focus on (1) improving public access on designated trails, (2) restoring the creek riparian corridor, (3) creating a more structurally diverse urban forest habitat for wildlife, and (4) creating increased and more sustainable populations of sensitive plant species. The SNRAMP stated that "[i]mplementation of the management recommendations at the Interior Greenbelt would not change significantly the overall look of the park" (EIP Associates 2006: 6.23-3).

In combination with the proposed activities of the proposed project, the City's management strategies for the Interior Greenbelt as defined in the SNRAMP Plan would not result in an alteration to the historic character of the Mount Sutro Cultural Landscape and would not result in a material impairment of its historical significance in association with Adolph Sutro and his development of the Sutro Forest (California Register Criterion 2 [Persons]) or with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for San Francisco (California Register Criterion 1 [Events]).

The proposed project is intended to provide a benefit by maintaining, improving and restoring the Reserve and would not contribute to long-term, adverse cumulative impacts on the Reserve as a historical resource. No other UCSF or City projects are currently proposed in a sufficiently close proximity such that cumulative impacts related to historical resources would be anticipated. Therefore, the proposed project would not contribute to cumulative adverse impacts related to historic resources.

## TABLE OF CONTENTS

I. EXECUTIVE SUMMARY ..... i

II. INTRODUCTION ..... 1

A. Proposed Project Background ..... 1
B. Purpose of the Cultural Landscape Evaluation Report ..... 2
C. Definition of the Mount Sutro Cultural Landscape Study Area ..... 3

III. METHODS ..... 4

A. Personnel ..... 4
B. Field Methods ..... 4
C. Research Methods ..... 4
D. Evaluation Methodology ..... 7

III. REGULATORY CONTEXT ..... 8

A. California Environmental Quality Act (CEQA) ..... 8
B. Other California Laws and Regulations ..... 9

IV. HISTORIC CONTEXTS ..... 10

A. Development of Stern Grove, Golden Gate Park and the Presidio Forest ..... 10
Stern Grove ..... 10
Golden Gate Park ..... 11
Presidio Forest ..... 14
B. Mount Sutro's Association with Late Nineteenth Century Afforestation in California ..... 16
Overview of Afforestation in California and San Francisco ..... 16
Key Species and Techniques Used in San Francisco Afforestation Efforts ..... 18
Eucalyptus in California ..... 20
C. Adolph Sutro's Role in Shaping the San Francisco Landscape ..... 22

V. EVOLUTION OF MOUNT SUTRO ..... 28

A. Pre-Contact Landscape ..... 28
B. Spanish and Mexican Period ..... 28
C. Start of the American Period ..... 29
D. Adolph Sutro and the Sutro Forest (1880-1898) ..... 30
E. Control of Mount Sutro by Sutro's Heirs (1898-1953) ..... 34
F. UCSF Period (1953-present) ..... 37

VI. EXISTING CONDITIONS ..... 39

A. Land Uses ..... 41
B. Natural Features ..... 41
C. Boundary Demarcations ..... 43
D. Spatial Organization ..... 45
E. Buildings and Structures ..... 45
F. Circulation Features ..... 46
G. Vegetation Features ..... 51
H. Small-Scale Features ..... 53

I. Archaeological Features....54
VII. EVALUATION....56
A. Summary of Significance and Period of Significance....56
B. Boundary....56
C. Character-Defining Features....57
D. Integrity....58
Summary of Integrity....58
Location....58
Design....58
Materials and Workmanship....61
Setting....62
Feeling....63
Association....63
E. Summary of the Evaluation....64
VIII. IMPACTS ANALYSIS....65
A. Proposed Project....65
Overview....65
Demonstration Areas....66
Continued Implementation....69
Trails....70
Ongoing Maintenance....71
Best Management Practices....71
B. Analysis of the Potential for Impacts to the Reserve as a Historical Resource....71
Four Demonstration Areas and the “Hands-off” Area....73
Continued Implementation....73
Trail System Improvements....74
Ongoing Maintenance....75
C. Cumulative Impacts Analysis....75
IX. BIBLIOGRAPHY....78

**Appendix**

**Figure 1:** Project Site

**Figure 2:** Mount Sutro Open Space Reserve

**Figures 3 to 19:** Historical Images

**Figures 20 to 50:** Photographs of Existing Conditions

**Figure 51:** Proposed Demonstration Project Areas

**Figure 52:** Proposed Trails

# II. INTRODUCTION

## A. Proposed Project Background

The University of California, San Francisco ("UCSF") proposes to implement a number of management actions in the UCSF Mount Sutro Open Space Reserve ("Reserve"). The Reserve is a largely undeveloped 61-acre forest located within UCSF's Parnassus Heights campus site at the center of San Francisco (see Figures 1 and 2). UCSF's hospital, research, educational and support structures are located on the north/northwest side of the Reserve, and urban residential neighborhoods border its south, east, and west sides. A portion of the Interior Greenbelt area, owned by the City of San Francisco, is immediately adjacent to the east side of Reserve, and another portion is located across Clarendon Avenue on its south side in the vicinity of Sutro Tower. The Reserve, designated as permanent open space by The Regents of the University of California in 1973, is open to the public and serves as a point of respite and recreation not only for UCSF but for the greater community.[1]

In 1996, UCSF prepared a Long Range Development Plan (LRDP) to guide the physical development of the campus. The LRDP reaffirmed UCSF's commitment to maintain the Reserve as permanent open space and included a proposal to investigate an appropriate maintenance and restoration program for the trees and vegetation in the Reserve. To fulfill this proposal, the Mount Sutro Open Space Reserve Management Plan (Management Plan) was prepared in 2001 to serve as a framework for future management activities. In 2009 and 2010, UCSF entered into a Community Planning Process to obtain community input for the potential forest management activities as recommended in the 2001 Management Plan. Based on this Community Planning Process, UCSF has refined the management strategies in the 2001 Management Plan and proposes to implement a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and plants and conversion to native species).

Vegetation management actions are proposed to occur throughout the Reserve over many years and would be phased beginning with four demonstration projects that were crafted with the interested public in the Community Planning Process. The first three demonstration projects are planned for implementation following the completion of environmental review and project approval. The fourth demonstration project would be implemented approximately one year after the first three demonstration projects. Also, a "Hands-Off" management area in which no vegetation management would be undertaken for the one-year duration of the demonstration project timeframe is proposed as requested by some community members. The demonstration projects would include a range of potential management actions that could be later implemented throughout the entire Reserve. Such actions would be first implemented in these four small areas to

[1] UCSF Campus Planning, 2010 *Notice of Preparation, Initial Study: University of California San Francisco, Mount Sutro Management, 10 December 2010* (San Francisco*:* UCSF Campus Planning), 1.

"demonstrate" to the public the range of potential results. Public feedback would then inform the University's choices in the management activities to be applied to the remainder of the Reserve over time. The management actions identified for the demonstration areas are proposed to be applied ultimately beyond the demonstration areas to the remainder of the Reserve, as appropriate, subject to further refinement by UCSF and its urban foresters in consultation with the interested public.[2]

UCSF has prepared an Initial Study in accordance with the California Environmental Quality Act (CEQA) (California Public Resources Code, Sections 21000-21177) and the Guidelines for Implementation of CEQA (California Code of Regulations, Title 14, Sections 15000-15387) to provide a preliminary evaluation of the proposed project and to determine upon which environmental topics the project may have a significant adverse effect requiring further analysis in an Environmental Impact Report (EIR). Those environmental topics, identified in the *Notice of Preparation/Initial Study: University of California San Francisco, Mount Sutro Management (*"Notice of Preparation/Initial Study"*),* for which the proposed project would have a "Less than Significant Impact," "Less than Significant Impact with Project Mitigation," or "No Impact," will not be analyzed further in the EIR. Topics for which the proposed project would have "Potentially Significant" environmental impacts will be analyzed in the EIR.[3] The Notice of Preparation/Initial Study identified environmental impacts to historical resources as "Potentially Significant" and stated that the "EIR will assess the Mount Sutro Open Space Reserve to determine whether it qualifies as a cultural landscape (i.e. a historical resource) and whether effects of the proposed project on historical resources will be significant."[4]

## B. Purpose of the Cultural Landscape Evaluation Report

This Cultural Landscape Evaluation Report was prepared to determine whether the Reserve qualifies as a historic resource under the California Register of Historical Resources criteria and to determine whether the proposed management activities would have a significant impact on a historic resource.

This Cultural Landscape Evaluation Report includes the following sections:

- A description of the field, research, and evaluation methodology.
- A summary of the regulatory framework.
- Historic contexts of Adolph Sutro's significance in shaping the cultural landscape in the western part of San Francisco, large-scale afforestation during the late nineteenth century, the use of eucalyptus, and short summaries of the development of other large-scale forests in San Francisco.

[2] Ibid., 4-5.
[3] Ibid., 2.
[4] Ibid., 26.

- A history of the evolution of Mount Sutro.
- A description and analysis of the existing conditions within the Reserve.
- An evaluation of the significance and integrity of the Reserve as the major portion of the Mount Sutro Cultural Landscape under the California Register of Historical Resources criteria.
- An evaluation of the potential impacts from the proposed management activities to those character-defining features that reflect the Reserve's historical significance as the major portion of the Mount Sutro Cultural Landscape.
- A bibliography of references used to prepare this report.
- An appendix with historic photographs and photographs of the existing conditions of the Reserve's character-defining features.

## C. Definition of the Mount Sutro Cultural Landscape Study Area

Within the framework of cultural resources analysis, the Reserve can best be described as a cultural landscape.[5] For the purposes of the analysis in this Cultural Landscape Evaluation Report, the term "Mount Sutro Cultural Landscape Study Area" refers to the 61-acre Reserve that is owned and managed by UCSF, and the 12-acre portion of the Interior Greenbelt adjacent to and contiguous with the east side of the Reserve that is owned and managed by the City and County of San Francisco. No survey of the Interior Greenbelt was conducted for the historic resource evaluation in this report, as it is outside the Reserve's boundaries and beyond the jurisdiction of UCSF; nonetheless, the Interior Greenbelt is considered part of the Mount Sutro Cultural Landscape Study Area in the analysis in this report.

[5] Cultural landscapes are considered to be geographic areas shaped by human activity; they can result from a conscious design or plan, or evolve as a byproduct or result of people's activities; and they may be associated with a historic event, activity, or person or exhibit other cultural or aesthetic values (NPS 1996, 4).

# III. METHODS

## A. Personnel

This Cultural Landscape Evaluation Report was prepared by cultural landscape specialist Denise Bradley in association with Knapp & VerPlanck Preservation (KVP) Architects.

Christopher VerPlanck, partner in KVP Architects, conducted research, managed the project, and served as the liaison between UCSF and the rest of the project team. Mr. VerPlanck (M.A. History of Architecture, University of Virginia) has extensive experience in architectural history and historic preservation practice in San Francisco and the West and meets the Secretary of the Interior's Historic Preservation Professional Qualifications for Architectural Historians and Historians. Christopher Pollock, local historian and designer, also provided research assistance.

Denise Bradley, ASLA, conducted the field work and a portion of the research, evaluated the significance of Mount Sutro as a cultural landscape, and was the principal author of the report. Ms. Bradley (M.L.A. Landscape Architecture, Louisiana State University) has 17 years of experience as a landscape historian in California and meets the Secretary of the Interior's Historic Preservation Professional Qualifications for Historical Landscape Architects and Historians.

## B. Field Methods

Denise Bradley conducted an intensive survey of the cultural landscape at Mount Sutro during December 2010 and January 2011.

## C. Research Methods

The focus of the research for this Cultural Landscape Evaluation Report was a review of primary and secondary sources for information that would aid in the evaluation of the significance of the Reserve as a historic resource.

Repositories that were consulted included the San Francisco Public Library (including the San Francisco History Center and the San Francisco Historical Photo Collection), the University of California, Berkeley's Bancroft and Earth Sciences libraries, the California Historical Society collections, the Pacific Aerial Surveys' collection, a variety of online repositories, and the libraries of the consultants.

Richard Brandi's article "Farms, Fire and Forest: Adolph Sutro and Development 'West of Twin Peaks,'" published in *The Argonaut* (Summer 2003) was utilized for a summary of the history of Adolph Sutro's development of the San Miguel Rancho; Brandi did extensive primary research for this article and included detailed footnotes with this article.

Adolph Sutro's 1895 letter to the University of California Regents proposing to donate land for the Affiliated Colleges on Parnassus Avenue briefly described his vision of Mount Sutro as an appropriate setting for the college and his library. Russ Davidson's article "Adolph Sutro as Book Collector: A New Look" published in the *California State Library Foundation Bulletin* (Spring/Summer 2003) provided a valuable background on Sutro as a book collector and his collection.

Descriptions of the Sutro Forest and Mount Sutro in the late nineteenth and early twentieth centuries were provided by a number of contemporary sources including E. S. Ryder's article "A Forest of Over a Million Trees in the Heart of San Francisco," published in the *San Francisco Chronicle* in 1896; Harold French's article "A Mountain Wilderness in the City's Heart," published in the *Overland Monthly* in 1905; and A. S. Baldwin's 1910 appraisal of the Sutro estate. Additionally, articles in local newspapers were reviewed for information about Mount Sutro during the late nineteenth and early twentieth centuries; these articles generally fall into two categories—those that are describing the scenic and recreational aspects of the forest and Mount Sutro and those mentioning fires in the forest. Craig Dawson (Executive Director of the Sutro Stewards) and Daniel Schnieder (film maker and local historian) provided a list of newspaper citations on fires from their research in emails to Judy deReus (UCSF Campus Planning).

Historical aerial photographs from the Pacific Aerial Surveys collection, the Map Room Aerial Photograph Collection in the University of California-Berkeley, Earth Sciences Library, and those assembled on Google Earth were reviewed. Historical photographs of Mount Sutro and of the Sutro Forest were reviewed in A. S. Baldwin's 1910 appraisal of the Sutro Estate, in the San Francisco History Center Collection, and through images reproduced in books on San Francisco from Arcadia's *Images of America* series (Brandi 2005, Cohen 2008, Gaar and Miller 2006, Garibaldi 2007, Proctor 2006, and Ungaretti 2003). A range of historical maps were also reviewed.

Previous reports that have been prepared about the cultural resources on the UCSF Parnassus Campus were consulted for historic context information (Carey & Co., Inc. 2003 and 2010, Miley Paul Holman 1998, and URS Inc. 2008). Previous reports prepared on proposed management plan for the forest were also reviewed (HortScience et. al. 1999, EDAW 2001, and UCSF 2010a and 2010b).

Information for the historic contexts for late nineteenth-century afforestation, the development of large-scale forests in San Francisco, late nineteenth-century landscape design principles, the use of eucalyptus and forestry practices in California during the late nineteenth century, and Adolph Sutro's significance in shaping the cultural landscape in the western part of San Francisco utilized research in previous reports prepared by the consultant (Bradley 2005, Bradley 2009, Bradley and Corbett 1999, Bradley and Corbett 2004).

Information on the history of the Nike site at Mount Sutro and the Nike program came from Erwin N. Thompson's *Historic Resource Study: Seacoast Fortifications San Francisco Harbor* (1979) and two websites (The Military Standard and Jef Poskanzer's Nike Missile Sites of San Francisco Bay Area). David July's website 'Mount Sutro: An Electronic Periodical" provided information on the development of the areas surrounding Mount Sutro.

Craig Dawson (executive director of the Sutro Stewards) and Daniel Schnieder (film maker and local historian) discussed their research on the history of the trail system and the forest within the Reserve in personal communications with Denise Bradley.

The *Cultural Resources Technical Report: Mount Sutro Vegetation Management, University of California, San Francisco*....(URS Inc. 2008) which was prepared as part of the Section 106 compliance related to a FEMA grant that UCSF applied for in 2007 and 2008 (but ultimately withdrew its application for) included a prehistoric and historic site record and literature search completed by the California Historical Resources Information System, Northwest Information Center at Sonoma State University in Rohnert Park (NWIC File No. 07-0842). Appendix B in this report includes the results of this record search and Appendix D includes copies of the correspondence with the Native American Heritage Commission. This record search found that no resources have been previously recorded within the Reserve.[6] A record search of the sacred land file failed to indicate the presence of Native American cultural resources in the immediate project area,[7] and no responses were received to the letters sent to the Native American Contacts. No additional record search or Native American Heritage Commission consultation was conducted for this Cultural Landscape Evaluation Report.

A full list of the references is provided in the bibliography.

For the sake of consistency, the name Mount Sutro is used throughout this report. Known by several names throughout the European, Mexican, and American periods, it was originally named "Blue Mountain" by Frederick William Beechey, captain of the British Royal Navy ship *H.M.S. Blossom* around 1826 or 1827. It was labeled as such on the 1895 and 1898 USGS topographic quads and is referred to by this name in newspaper articles from the early 1900s. Sutro unofficially renamed it to "Mount Parnassus." In 1910, the Sierra Club proposed renaming the peak as "Sutro Crest," but Emma Sutro Merritt, Sutro's daughter and the executrix of his estate, "objected" to this name, and in 1911 the name Mount Sutro was made the official designation.[8]

[6] Bryan Much (Researcher I, Northwest Information Center), Memo to Maureen S. Kick (NWIC File No. 07-0842), RE: Records Search Summary Letter for Vegetation Management Project (17 January 2008), 1.
[7] Debbie Pilas-Treadway (Native American Heritage Commission), Letter to Maureen S. Kick (URS Corporation), 2007.
[8] David July, Mount Sutro: An Electronic Periodical, 2011.

## D. Evaluation Methodology

The California Register of Historical Resources (CRHR) criteria were used in evaluating the historical significance of the Reserve as a cultural landscape. The California Office of Historic Preservation's *Technical Assistance Series #6: California Register and National Register: A Comparison (for purposes of determining eligibility for the California Register) and Technical Assistance Series #7: How to Nominate a Resource to the California Register of Historical Resources (Revised 2001)* were consulted in relation to the CRHR criteria. The CRHR does not provide specific guidance for describing cultural landscapes. However, the CRHR was consciously designed on the model of the National Register of Historic Places (the two programs are extremely similar, although there areas in which these programs differ), and guidance provided in National Register and National Park Service publications were used in describing the existing conditions on Mount Sutro. These publications included the National Park Service publications – *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*, *National Register Bulletin 18: How to Evaluate and Nominate Historic Designed Landscapes*, and *National Register Bulletin 30: How to Evaluate and Document Rural Historic Landscapes* provided additional guidance on the evaluation of cultural landscape features. *A Guide to Cultural Landscape Reports: Contents, Process, and Techniques* was consulted on the procedures related to research and documentation for cultural landscapes; and *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes* was consulted related to the Proposed Project's vegetation management activities in relationship to the Reserve as a historically-significant cultural landscape.

# III. REGULATORY CONTEXT

## A. California Environmental Quality Act (CEQA)

Under the California Environmental Quality Act (CEQA), public agencies must consider the effects of their actions on both "historical resources" and "unique archaeological resources." Pursuant to Public Resources Code (PRC), Section 21084.1, a "project that may cause a substantial adverse change in the significance of an historical resource is a project that may have a significant effect on the environment."

"Historical resource" is defined by statute (see PRC, Section 21084.1 and CEQA Guidelines section 15064.5 [a] and [b]). The term covers any resource listed in or determined to be eligible for listing in the CRHR. The CRHR includes resources listed in or formally determined eligible for listing in the National Register of Historic Places (NRHP), as well as some California State Landmarks and Points of Historical Interest.

Properties of local significance that have been designated under a local preservation ordinance (local landmarks or landmark districts) or that have been identified in a local historical resources inventory may be eligible for listing in the CRHR and are presumed to be "historical resources" for the purposes of CEQA unless a preponderance of evidence indicates otherwise (PRC, Section 5024.1; California Code of Regulations, Title 14, section 4850). Unless a resource listed in a survey has been demolished, lost substantial integrity, or there is a preponderance of evidence indicating that it is otherwise not eligible for listing, a lead agency should consider the resource to be potentially eligible for the CRHR.

In addition to assessing whether historical resources potentially affected by a proposed project are listed or have been identified in a survey process, lead agencies have a responsibility to evaluate them against the CRHR criteria prior to making a finding as to a proposed project's impacts on historical resources (PRC, Section 21084.1; CEQA Guidelines, section 15064.5[a][3]). In general, a historical resource, under this approach, is defined as any object, building, structure, site, area, place, record, or manuscript that:

a. Is historically or archaeologically significant; or is significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political or cultural annals of California; and,

b. Meets any of the following criteria:

    1. Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage;

    2. Is associated with the lives of persons important in our past;

3. Embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of an important creative individual, or possesses high artistic values; or,

4. Has yielded, or may be likely to yield, information important in prehistory or history.

Potential eligibility for the CRHR also rests upon the integrity of the resource. Integrity is defined as the retention of the resource's physical identity that existed during its period of significance. Integrity is determined through consideration of the setting, design, workmanship, materials, location, feeling, and association of the resource.

CEQA also requires lead agencies to consider whether projects will affect "unique archaeological resources." PRC, Section 21083.2(g) defines "unique archaeological resource" as an archaeological artifact, object, or site about which it can be clearly demonstrated that, without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

1. Contains information needed to answer important scientific research questions and that there is a demonstrable public interest in that information.

2. Has a special and particular quality such as being the oldest of its type or the best available example of its type.

3. Is directly associated with a scientifically recognized important prehistoric or historic event or person" (PRC, Section 21083.2 [g]).

Treatment options under PRC, Section 21083.2 include activities that preserve such resources in place in an undisturbed state. Other acceptable methods of mitigation under PRC, Section 21083.2 include excavation and curation or study in place without excavation and curation (if the study finds that the artifacts would not meet one or more of the criteria for defining a "unique archaeological resource").

## B. Other California Laws and Regulations

Other state-level requirements for cultural resources management appear in the PRC Chapter 1.7, Section 5097.5 "Archaeological, Paleontological, and Historical Sites," and Chapter 1.75 beginning at Section 5097.9 "Native American Historical, Cultural, and Sacred Sites" for lands owned by the state or a state agency.

The disposition of Native American burials is governed by Section 7050.5 of the California Health and Safety Code and PRC, Sections 5097.94 and 5097.98, and fall within the jurisdiction of the Native American Heritage Commission (NAHC).

## IV. HISTORIC CONTEXTS

Historic contexts on large-scale forests in San Francisco that were developed during the late nineteenth century, the principles underlying large-scale afforestation during this period, the use of eucalyptus in California, and Adolph Sutro's significance in shaping the cultural landscape in the western part of San Francisco are provided below to provide a basis for evaluating the significance of the Reserve as a historical resource.

### A. Development of Stern Grove, Golden Gate Park and the Presidio Forest

During the last three decades of the nineteenth century, large areas of San Francisco were planted with trees on what had previously been sand dunes or unforested hillsides. The new forests dramatically changed the city's appearance along its western edge, from the Presidio of San Francisco south to the Ocean Avenue area. During this era, planting trees was widely accepted as a practical and aesthetic improvement to the natural state of the landscape, which was perceived as barren, dry, and harsh to contemporary eyes – especially those from the East Coast or Europe. The trees at Stern Grove, Golden Gate Park, the Presidio of San Francisco, and in the Sutro Forest are all examples of these late-nineteenth-century, large-scale, tree-planting efforts of which portions continue to survive today. Their history provides valuable comparisons and contrasts to the development of the Sutro Forest and the Mount Sutro cultural landscape.

The forest at Stern Grove represents one of the earliest eucalyptus plantings in San Francisco. William Hammond Hall's seminal 1871 plan for Golden Gate Park was influential in the development of the forest within the Presidio of San Francisco (the Presidio Forest) and likely also influenced Adolph Sutro's plantings. The forest development within Golden Gate Park is documented in a written and graphic plan and benefited from the ongoing oversight of strong individuals (William Hammond Hall and later John McLaren) who championed the design and provided some level of maintenance continuity. The Presidio Forest is also a designed landscape and is based on an 1883 plan, but its development was impacted by a lack of professional oversight, which explains some of the problems within the present-day forest that are being addressed by The Presidio Trust, and which are similar to the conditions and problems facing the forest at Mount Sutro.

#### *Stern Grove*

In 1847, George M. Greene left Maine with his wife, and led a wagon train to California where they had been "advised by a friend in the Government service of excellent farming and cattle lands open to homesteaders."[9] Greene staked out a claim to 160 acres within the vicinity of present-day Sloat Boulevard and 19th Avenue. His holdings, which were later expanded by 25 acres, included the present-day Stern Grove and Pine Lake Park site. His two brothers, Alfred and

[9] George M. Greene [Jr.], "Historical Events Pertaining to 'The Trocadero.'" (typewritten manuscript 1938), 1.

John, soon followed him to California, and between the three, they owned all of the land from the Stern Grove vicinity west to the ocean. The Greenes became part of the early Anglo-American community that developed in San Francisco's Outside Lands area (today's Parkside District) after the United States took control of California from Mexico in 1846.[10]

George M. Greene Jr., along with his father and two uncles, planted some of the earliest eucalyptus trees in San Francisco. The constant winds and shifting sands blowing across their fields and roads made farming and travel difficult and made the living areas around their homes unpleasant.[11] In response members of the Greene family planted eucalyptus trees as wind breaks and to help anchor the shifting sand dunes on their property. George Jr. planted the trees on the steep slopes of the family's home (today's Stern Grove and Pine Lake Park) in the early 1870s.[12] As with other forest planting efforts in San Francisco during the late nineteenth century, Greene planted eucalyptus, Monterey cypress, and Monterey pines; he also planted "Holland grass" to help stabilize the sand dunes. Today, this forest continues to exist on the slopes that encircle the park. The trees continue to be a character-defining feature of this part of the city and have been identified as a contributing feature to the Stern Grove and Pine Lake Park NRHP-eligible historic district.[13]

### *Golden Gate Park*

The sand dune reclamation and tree-planting methods that were at the core of William Hammond Hall's seminal 1871 plan for Golden Gate Park were key to the development of the Presidio Forest and likely also influenced Adolph Sutro. Hall wrote extensively about his work at Golden Gate Park, and an understanding of the development of the Golden Gate Park Forest—which predated the Sutro Forest by almost fifteen years—sheds light on the development of Mount Sutro.

San Francisco had acquired the land for Golden Gate Park in the late 1860s as a part of the 1865 settlement of the ownership of the Outside Lands (land west of the city's original 1851 charter). The Golden Gate Park site was one of three potential sites that were actively promoted during the 1860s for a major park development (the other two were the Presidio and the area to the south of the city core known as Mission Valley), and early appraisals of this particular area were resoundingly negative. One San Francisco newspaper described the site as a "white elephant" and a "dreary waste of shifting sandhills where a blade of grass cannot be raised without four posts to keep it from blowing away." This description probably reflected the majority of San Franciscans opinion of most of the Rancho San Miguel tract that Sutro purchased. The realities of the climate (that included a prolonged dry season with low rainfall) and the conditions

[10] Greene [Jr.} 1938, 1; Marsha Fontes, "Stern Grove" in *West Portal Monthly* (December 1991), 9.
[11] Fontes 1991, 9.
[12] Greene [Jr.] 1938, 2.
[13] Denise Bradley and Michael Corbett, *Final Draft, Cultural Landscape Report with National Register and California Register Evaluation for the Stern Grove and Pine Lake Park Historic District* (July 2004), 11.

(extensive sand dunes and constant winds) challenged the concept for a typical East Coast-style romantic park that the city was expecting to create on this site.

The goal of the romantic park was to provide the visitor with an experience of being in "an unspecified and unbounded rural landscape composed of water features, lawns, shrubs, and trees," and the mid-nineteenth century landscape of the western part of San Francisco did not conform to this ideal.[14] The majority of San Franciscans were from Europe or the east coast, southern, or Midwestern states, and their preconceptions of what was beautiful and what a landscape should look like were based on their past experiences which they brought with them from these other places. Much of the transformation of the city's landscape (i.e., Golden Gate Park, the Presidio Forest, and possibly the Sutro Forest) was undertaken in an attempt to recreate what was familiar to these early San Franciscans.[15]

In late 1871, under the auspices of William Hammond Hall, work began on the development of the 1,017-acre park. Hall had been hired to survey the park in 1870 and was then appointed as the Engineer of the Park in August 1871.[16] Although Hall had no formal experience in landscape design prior to developing his plan for Golden Gate Park, he was nevertheless well-qualified. He had a thorough understanding of local climatic and site conditions through his work with the Army Corps of Engineers. He had worked as a field engineer for the Army Corps between 1866 and 1870 and had surveyed areas along the west coast from San Diego to Washington state, including 3,000 acres of land in the sand dunes (Outside Lands) west of San Francisco. He had also surveyed and prepared a map of the Presidio (published in 1870). Colonel Barton S. Alexander, the ranking officer of the Army Corps of Engineers and under whose command Hall worked, recommended him for the survey of the park site. Russell Beatty, in his history of the planting process at Golden Gate Park, states that "Alexander clearly believed that by supporting Hall to survey the park, the city's interest in the Presidio as a park site would be diverted."[17]

Hall conceived an ambitious plan to stabilize the dunes and plant trees based on principles he gathered from writings on similar situations in Europe and North Africa. He determined that the techniques used along the coast of the Bay of Biscay (Gulf of Gascony) in France were the most applicable to San Francisco (although different plants species were ultimately used in San Francisco). As part of his preparation of the Golden Gate Park plan, Hall acquired a wide range of park plans and writings on the "more desirable [sic] works on Landscape gardening & Park improvement." He also wrote to Frederick Law Olmsted for

[14] Terence Young, *Building San Francisco's Parks, 1850-1930* (Baltimore, MD and London: The Johns Hopkins University Press, 2004), 5-7.
[15] David C. Streatfield, "Where Pine and Palm Meet: The California Garden as a Regional Expression" in *Landscape Journal* (1985), 62 and *California Gardens* (1994), 36.
[16] Russell A. Beatty, "The Planting of Golden Gate Park: A Metamorphosis in Sand" in *The Trees of Golden Gate Park and San Francisco*, Elizabeth McClintock (Berkeley, CA: Heyday Books/Clapperstick Institute, 2001), 1, 4, and 6.
[17] Beatty 2001, 3.

advice, who Hall knew from his reputation as the expert in the field, thus beginning a decades-long correspondence between the two, and reviewed the first Annual Report (1858) for Olmsted's Central Park. Hall also brought to this project extensive travel experience that he described in his initial letter to Olmsted. He noted that he had visited the Andrew Jackson Downing–inspired country estates along the Hudson River in New York and had visited and "carefully studied and noted the principal parks and grounds" in London, Paris, and the United States. He had visited Central Park, Prospect Park (in Brooklyn), Fairmount Park (in Philadelphia), and Druid Hill Park (in Baltimore). Hall adapted the ideas reflected in these parks to the Golden Gate Park site. During the park's critical first five years, he successfully laid out the key components of his design, reclaimed sand dunes, and established the park's forests.[18]

Hall set about to systematically adapt the natural environment to his design for the park and to address related problems on several major fronts. An artificial berm was built along the beach at the western end of the park by erecting wood posts piled with brush to prevent additional sand from blowing into the park. Lupine (a native plant) and nonnative brushy plants (including albizia, acacia, and *Pinus pinaster*) were planted to stabilize the sand dunes in the western two-thirds of the park. Once stabilized, the dunes were planted with ornamental vegetation. A belt of trees was planted to protect the panhandle and the eastern portion of the park. After having accomplished these steps, Hall directed the planting of the panhandle and laid out roads, walks, and "other improvements." This area, located on the east side of the park site, was the most accessible and therefore the most visible to the city's population.[19]

One of the first things that Hall did was establish a nursery and greenhouse to grow the trees that he would be planting. By doing this, he was able to save money and experiment to see which trees were best-suited for his needs. "Hall discovered to his delight that his nursery-reared trees grew at an astonishing rate. In only two years, eucalyptus seedlings shot up to eighteen feet with a caliper of four inches. Monterey pines and Monterey cypress reached fourteen feet with a spread of ten to twelve feet during the same period. He adopted an intelligent planting scheme, planting the trees closely so that would support each other against the buffeting winds; the trees would later be thinned as they matured."[20]

Within three years, Hall set out over 66,000 trees, with eucalyptus, Monterey cypress, and Monterey pine being the three predominant species planted (as well as other species that evidently did not survive). By the end of the decade, the park featured two miles of roads and paths and more than 135,000 trees and shrubs had been planted.[21]

[18] Young 2004, 74-75 and 80-81.
[19] Young 2004, 84-87 and 231; Beatty 2001, 9-10; San Francisco Board of Park Commissioners, *First Biennial Report of the San Francisco Park Commissioners, 1870-1871* (1872).
[20] Beatty 2001, 7.
[21] Beatty 2001, 6-8.

Hall described (and defended) his planting methods in an 1886 publication, *The Development of Golden Gate Park and Particularly the Management and Thinning of its Forest Tree Plantations,* that was prepared by San Francisco's Board of Park Commissioners. By 1886, the park faced problems associated with the thickly-planted stands of trees that had not been thinned as Hall had envisioned. The Army faced similar issues in the Presidio's overgrown and overcrowded forest in 1902 when William L. Hall made recommendations related to thinning and pruning in his *Plan for the Improvement and Extension of the Forest on the Military Reservation of the Presidio of San Francisco, California*. Emma Sutro Merritt addressed this same issue in 1909 with the Sutro Forest.

### *Presidio Forest*

Like Golden Gate Park, the design for the Presidio Forest has its roots in the practice of large-scale afforestation efforts that were underway in California during the late nineteenth century and in the romantic park design principles of this era as applied to the mass planting of trees. Major William A. Jones, a member of the U.S. Army Corps of Engineers, developed the plan, "Plan for the Cultivation of Trees Upon the Presidio Reservation", that provided the rationale and blueprint for the development of the Presidio Forest. He submitted his report to the Assistant Adjutant General at the Department of California in March 1883. His proposals addressed a number of pragmatic and concrete goals that involved stabilizing the areas of the reservation that consisted largely of shifting sand dunes, providing protection from prevailing ocean winds in the settled areas of the reservation, improving the appearance of the reservation in the eyes of San Franciscans, and creating a visual boundary between the Presidio and San Francisco. Although nominally a plan to guide afforestation, Jones' report actually addressed the creation of a park-like landscape at the Presidio. Jones envisioned this landscape as a way to express the identity of the Presidio and as a symbol of the authority of the U.S. government on the reservation. His plan addressed aesthetic, functional, and technical issues related to tree planting, and also made recommendations that dealt with the experience of movement through the landscape, with the framing of views, and with the composition of features within the landscape. He strove to create a spatial and visual composition for the landscape at the Presidio that established a distinctive identity for the reservation which conformed to the era's romantic or idealized view of nature.

Jones provided little information on the influences for his ideas at the Presidio, but his concepts were likely inspired and guided by William Hammond Hall's successful plan for the new Golden Gate Park. By 1883, Golden Gate Park's plantings were well-established, and the design was generally considered a success. The conditions at the Presidio were similar to those at Golden Gate Park, and although Jones only cited Hall's methods for propagating trees at Golden Gate Park in his report, he was undoubtedly familiar with Hall's work. It is also possible that he knew Hall, since both had backgrounds as engineers in the U.S. Army Corps of Engineers.

Jones developed his plan using the aesthetic assumptions—based on the English landscape school of design—that were typical of park design in America during the second half of the nineteenth century. His plan was part of the nationwide movement to create large-scale, park-like landscapes popularized by the writings of Andrew Jackson Downing and then realized by Frederick Law Olmsted's and Calvert Vaux's designs for New York's Central and Prospect parks and, locally, by William Hammond Hall's design for Golden Gate Park.

Jones' understanding of the reasonableness of reshaping or "improving" the physical environment through afforestation was influenced by these ideals. The critical period for the implementation of Jones' 1883 plan was between 1886 and 1895 when the general location of the forest and its overall character-defining features were established. A second phase of development occurred between 1902 and 1906 as described in the 1902 report *Plan for the Improvement and Extension of the Forest on the Military Reservation of the Presidio of San Francisco*, prepared by William L. Hall, chief of the U.S. Department of Agriculture's Division of Forest Extension. Hall studied the 420-acre forest that existed at the Presidio in 1902, which had been developed based on the ideas and vision presented in Jones' 1883 plan, and provided his analysis—as a forester—on the Presidio Forest's existing conditions.

The planting density, monocultural character of stands of trees, and lack of a thriving understory which ended up characterizing the forest came about largely as the result of the Army's planting methods and by its management of the forest – in particular by maintenance practices such as the lack of thinning and the practice of topping – rather than as a direct result of the Jones plan. In fact, the Army's implementation and management practices resulted in the failure of Jones' 1883 plan from being fully realized. At Golden Gate Park, the success of the tree planting and of the larger park design was aided by the ongoing presence of fiercely protective superintendents (initially William Hammond Hall and later John McLaren) who provided continuity in oversight for the multi-year project and who championed the planting efforts and the ultimate design for the park.[22] There was no such person at the Presidio; Major Jones was transferred before any real planting began. The implementation of Jones' plan was nominally under the oversight of the Quartermaster's Office and was dependent on annual funding, available labor, and, to some extent, the interest of successive commanding officers. Similarly, the Sutro Forest, in general, and the Mount Sutro area, specifically, lost this oversight when Adolph Sutro died in 1898.

A description of the problems that arose from this lack of professional oversight at the Presidio also helps to explain similar conditions that developed within the Mount Sutro Forest. Major Jones recommendation that "[t]rees in masses should

[22] William Hammond Hall had remained at the park from 1871 to 1876, long enough to establish the eastern portion of the park and to firmly establish the sand dune reclamation efforts in the western portion of the park. This enabled the park to survive a "dark decade" of neglect until the arrival of John McLaren, the legendary superintendent, who remained unequivocally in charge of the park from 1887 until his death in 1943.

be planted very thickly" at the Presidio was followed; however, his companion directive to conduct annual thinning was for all intents and purposes left undone. Additionally, while there were some problems with tree loss during the initial planting phase, the majority of trees did survive, and because of the lack of thinning the stands matured within an overcrowded growing environment. This overcrowding produced individual trees that had tall, thin trunks, a small canopy located at the top of the trees, and few lower branches. Additionally, these characteristics within the overwhelmingly evergreen stands resulted in low light conditions that contributed to the limited establishment of understory vegetation. The geometric layout of the trees (in rows or a grid) was a result of expediency in planting the trees on the Army's part rather than being a key characteristic of Jones' plan.

Jones' 1883 narrative report did not explicitly address understory plantings within the forest. However he mentioned a fairly wide range of shrub species to be planted and seemed to imply that once the evergreen trees became established—and mitigated some of the impacts of the westerly winds on the growing environment at the Presidio—that the variety of tree species (some of which would be classified as understory) could be expanded: "…it is doubtful whether they [deciduous trees] can be successfully cultivated, except in sheltered sites and among masses of other trees. In the outset, therefore, we are almost restricted to evergreen trees that continue their growth during the winter season." The full range of tree and shrub species included in Jones' 1883 report was never planted. Instead, a narrow range of primarily evergreen species were planted that were readily available in California at the time and that had proved to be hardy and adapted to the site conditions when used at Golden Gate Park. The most commonly planted trees included blue gum eucalyptus, Monterey cypress, Monterey pine, and blackwood acacia. The establishment of these primary groves consumed all of the Army's available resources, efforts, and funding, and without a designer to oversee the long-term development of the forest, the full extent of the planting design in Jones' report was never achieved.[23]

## B. Mount Sutro's Association with Late Nineteenth Century Afforestation in California

### *Overview of Afforestation in California and San Francisco*

A key influence in the creation of the Sutro Forest,[24] which includes the Mount Sutro Cultural Landscape Study Area, were late nineteenth-century afforestation practices that viewed planting trees as a way to address concerns over a diminishing resource and as a way to improve the land. The importance and desirability of trees was partly based on the same ideals as those that were

[23] Denise Bradley, *Historic Forest Character Study, Presidio of San Francisco, San Francisco, CA* (2009), 15-18 and 78-81.

[24] In 1886, Adolph Sutro began a massive tree planting effort within the 1,200-acre San Miguel Rancho parcel that resulted in what became known as the Sutro Forest; the forested area on Mount Sutro was originally part of Sutro Forest. Refer to to "Adolph Sutro's Role in Shaping the San Francisco Landscape" and "Adolph Sutro and the Sutro Forest" later in this report for more information.

shaping romantic park design during this era. Added to this was an urgent desire to protect forest and timber resources that had become a national and state focus in the 1860s. Mass tree plantings were undertaken throughout California and locally in San Francisco during the last decades of the nineteenth century.

Gayle Groenendaal, in her paper on the history of the eucalyptus in California, explained that one of the key influences on the development of forestry practices in the latter part of the nineteenth century was a paper by the Reverend Frederick Starr in the report of the Department of Agriculture for 1865. Starr "predicted a timber famine within 30 years and advocated the immediate undertaking of carefully planned research on how to manage forests and how to establish plantations, especially of hardwood trees. This paper was to play an important role in the nation. It became an impetus of the forest movement that would eventually see the founding of the U.S. Forest Service. It was also a prime force behind the development of the Eucalyptus Boom in California."[25]

In California, massive immigration after the discovery of gold in 1849 resulted in an increased demand for lumber (the primary building material) and for firewood (the primary fuel for heating and cooking), and as a result, the state's forests were cut indiscriminately to provide for these needs. The state legislature passed a timber protection law in 1862 that prohibited cutting trees on both private land and public streets. A subsequent law called the Tree Culture Act of 1868q "encouraged the planting of shade and fruit trees along California roads. In it the various county boards of supervisors were given the responsibility of coordinating the effort within their jurisdiction. Growers would get $1 per planted tree after the tree had grown for four years." Although this project was not very successful (due to lack of public interest and budgetary constraints), it did establish the policy of the state promoting tree plantings and initiated an early process to encourage and coordinate large-scale tree planting. The federal government also promoted tree planting; a federal law was passed in 1873 that gave 160 acres to anyone who planted 40 acres of trees and maintained them for eight years. By the late 1860s, tree planting had come to be viewed as a patriotic duty throughout the country.[26]

Throughout California, various large-scale, tree-planting efforts altered the state's landscape. The *California Horticulturist* ran an article in its August 1876 issue that observed that "in California everything is done on a large scale if at all. Grape vines are planted by the hundreds of thousands, and wheat fields extend to thousands of acres, and the groves of the forest trees are what in the East would be called extensive forests. Of late Californians have commenced the planting of forest trees, and this, too, upon the same extended scale which marks all their operations."[27]

[25]Gayle Groenendaal, "History of Eucalypts in California: Eucalyptus Helped Solve a Timber Problem, 1853-1880" (1983), 2.
[26] Robert Santos, *The Eucalyptus of California: Seed of Good or Seeds of Evil?* (DeNair, California: Alley-Cass Publications, 1997), 20-21.
[27] Quoted in Groenendaal 1983, 4.

During this era, tree planting was part of a popular philosophy that advocated afforestation for a wide variety of benefits. Charles Shinn, one of the first to address horticulture and landscape design through the lens of California's growing conditions, recommended in his *Pacific Rural Handbook* that: "A judicious planting of tall and well foliaged trees…breaks the wind, ameliorates the climate, saves fuels, and adds beauty to the landscape in summer and winter."[28]

### *Key Species and Techniques Used in San Francisco Afforestation Efforts*

Three trees dominated these plantings in San Francisco: eucalyptus (primarily *Eucalyptus globulus* [blue gum]), Monterey cypress (*Cupressus macrocarpa*), and Monterey pine (*Pinus radiata*). The experimentation by William Hammond Hall, during his oversight of the first five years of the development of Golden Gate Park (1871-1876), established that these trees grew quickly, were able to withstand local site and climate conditions, and were ideally suited to the goals and the techniques of the late-nineteenth century afforestation process.

Monterey cypress and Monterey pine were native California species that were adapted to the planting environment along California's coastline. Monterey cypress was the acknowledged favorite species for use in windbreaks along California's coast due to their ability to "thrive in areas where they are drenched in moisture from the annual summer fogs along the coast."[45] Although native to California, Monterey cypress occurred naturally only on the Monterey Peninsula in two localized groves; however, by the early twentieth century, they were the most-widely-grown cypress in California. John McLaren, the superintendent of Golden Gate Park and one of the foremost horticultural authorities in the state, wrote in 1908 that the Monterey cypress "makes an excellent wind-break and stands exposure as well as, if not better than, any tree we have experimented with [at Golden Gate Park]."[29]

McLaren also wrote the following about the use of these three species in relationship to the establishment of the forest at Golden Gate Park:

> "A great many different species of trees were experimented with, including those especially suggested by European foresters… In exposed situations all of these, with the exception of Maritime Pine, failed entirely. At the same time, many of our native trees and shrubs, including Monterey Cypress, Monterey Pine, Yellow Pine as well as Alders and Maples were set out. The Cottonwood, Scrub Oak, and other varieties of Oaks, were also given a trial… the Monterey Cypress and Monterey Pine alone stood the test of braving the storms and the blasting influence of the Summer winds in the more exposed places and the district close to the shore. Seeds of a great many trees were also introduced from Australia

[28] Charles Shinn, *Pacific Rural Handbook* (San Francisco: Charles H. Shinn, 1878), 30.
[29] John McLaren, *Gardening in California, Landscape and Flowers,* 3rd edition (San Francisco, CA: A.M. Roberson, 1908, revised 1914 and 1924), 93.

> and New Zealand as well as from South America… the Acacia longifolia and the Leptospermum proving two of the best for this sort of work [sand reclamation efforts], these forming a close thicket of twiggy stems which provided perfect shelter for other species not so hardy. Eucalyptus of many species were set out by thousands, but only the common Blue and the rugged Red Gum were a success in the poorer sands." [30]

Lupine (a native plant) and other nonnative brushy plants (including albizia, acacia, and *Pinus pinaster*) were generally planted to stabilize the sand dunes in the Outside Lands areas where forests were established (i.e., Golden Gate Park, the Presidio, and throughout the Sutro Forest). Then the major fast-growing species (eucalyptus, Monterey cypress, and Monterey pine) were planted closely together so that they would support each other against the buffeting winds. Russell Beatty summarized William Hammond Hall's pioneering efforts using this technique to establish the plantings in Golden Gate Park

> "In only two years, eucalyptus seedlings shot up to eighteen feet with a caliper of four inches. Monterey pines and Monterey cypress reached fourteen feet with a spread of ten to twelve feet during the same period. He adopted an intelligent planting scheme, planting the trees closely so that would support each other against the buffeting winds; the trees would later be thinned as they matured."[31]

This method was adopted by Jones in his plan for the Presidio Forest, and during the first Arbor Day plantings at Yerba Buena Island in 1886, Adolph Sutro recommended planting the trees two to three feet apart.[32]

As Hall explained, when writing about his experiences at Golden Gate Park, this planting technique assumed that some trees would die ("The planting of trees was done in the expectation that full twenty-five percent might fail to grow"[33] and that the ones that survived would later be thinned as they matured ("trees were planted four to eight feet apart, in 1871 to 1876, with the view of gradually cutting out full two-thirds of the number within the years down to this time [1886]"[34]). Hall noted that "[t]his practice of planting thick, and afterwards thinning as the young trees commence to interfere with each other, in varied degrees" was a "universal custom in the cultivation of forest growths" in the late nineteenth century.[35] The practice continued to be recommended into the twentieth century. For example, Jones and forester G. B. Lull made recommendations (that went unheeded) to

[30] McLaren 1908, 329-330.
[31] Beatty 2001, 7.
[32] San Francisco Chronicle, "Arbor Day" (11 September 1886), 4.
[33] [San Francisco] Board of Park Commissioners, *The Development of Golden Gate Park and Particularly the Management and Thinning of Its Forest Tree Plantations* . . . (San Francisco: Bacon & Company, Book and Job Printers, 1886), 10.
[34] Ibid., 3.
[35] Ibid., 11.

thin the over-planted stands of the Presidio Forest in 1902 and 1906, respectively.[36]

### *Eucalyptus in California*

The nonnative eucalyptus became the species most closely identified with the late nineteenth century large afforestation efforts and became so widespread in the California landscape that, as Robert Santos observed in his narrative history of the tree, "It is difficult to imagine what California would look like [today] without the seemingly omnipresent eucalyptus."[37]

The genus *Eucalyptus* is native to Australia and has over 600 species. It is adapted to a wide variety of growing conditions and has been planted all over the world for its wood and its oil, as a windbreak to protect crops and settlements, and as an ornamental plant. Trees from the genus *Eucalyptus* have been the subject of interest, promotion, and myth for several hundred years. They were mentioned in explorers' journals from the mid-1600s, and botanist Joseph Banks, who accompanied James Cook on his explorations, collected specimens of eucalyptus on his travels and brought them back to England. A French botanist visiting England, Charles Louis L'Heritier de Brutelle, gave the genus *Eucalyptus* its scientific name.[38]

Botanists in Australia and France were writing extensively about eucalyptus in the mid-1800s and promoting its virtues. Eucalyptus was introduced into California in the mid- to late-1850s during a period of rampant horticultural experimentation and was one of many Australian plant species that were being planted in California during the last half of the nineteenth century.[39] Botanists and other enthusiasts wrote about the tree and promoted it as perfectly suited to California's climate and as an answer to concerns around the loss of the state's forests. Eucalyptus trees were viewed as particularly suitable to California because of their immense size, rapid growth rate, and adaptability to a wide range of growing conditions. Their medicinal uses and the mistaken reports that eucalyptus were fireproof added to the interest in the trees. Eucalyptus were also believed to increase rainfall and thus modify climate and to "absorb the malarial poisons." By the mid-1870s, the planting of eucalyptus was so prevalent in California that visitors to the state remarked on their prominence.[40]

This period, during the late nineteenth and early twentieth centuries, when an intense interest in planting eucalyptus gripped the state, is often referred to as the "Eucalyptus Boom." In fact, there were two eucalyptus booms in California.

[36] Wm. A. Jones, *Suggestions in the matter of parking the U.S. Military reservation of the Presidio of San Francisco*, 1902; G. B. Lull, *Report on a Preliminary Examination of the Military Reservations in and Around San Francisco Bay . . .* , 1906.
[37] Santos 1997, 4.
[38] Santos 1997, 4-10.
[39] Species of Australian plants began to appear in California during the 1850s and were included in the catalogs of the early nurseries in the East Bay. Their use became so prevalent that within a few years the San Francisco peninsula was described as being "more Australian than Australia" (Streatfield 1976, 45).
[40] Groenendaal 1983, 7.

The first boom, tied to the need for a ready source of wood, occurred during the last two decades of the 1800s and established eucalyptus as a part of the California landscape. The second wave of planting occurred between 1905 and 1912 and was driven by economic speculation in eucalyptus plantation plantings.[41]

During the first boom, eucalyptus trees were promoted by a wide range of interests. Private individuals who were eucalyptus enthusiasts helped to spread the interest for the tree. The railroads also played a key role in spreading eucalyptus trees throughout the state. In January 1877, both the Central and Southern Pacific Railroads announced intentions to plant eucalyptus trees all along their respective rail lines. For example, Southern Pacific planted 190,000 trees along its Anaheim branch in Los Angeles, and in a two-year planting period, between 1877 and 1879, the Central Pacific planted about 1,000,000 eucalyptus trees. The railroads were interested in eucalyptus for a number of reasons. The trees grew quickly and adapted to harsh growing conditions (though it seemed that cold was the only limiting condition that eucalyptus could not tolerate) so they could be counted on to provide wood needed to repair rail lines. However, the railroads soon abandoned the use of eucalyptus wood for rails when it proved to be too brittle. The trees also added an aesthetic appeal to railroad-owned land and were used in marketing the railroad companies' various real estate ventures.[42]

Public agencies contributed to the spread of eucalyptus throughout the state by their establishment of experimental stations to test-plant various species of the trees, through the publication of the results of these experiments, and through subsidies that consisted of providing free seedlings or paying a premium for planting the trees. Periodicals—including both the *California Farmer* and the *Pacific Rural Press*—printed articles that provided cultural information (planting, care, and economic viability), advertisements from nurseries that promoted the desirability of eucalyptus, and promotional seed giveaways that put this "miracle" tree into the hands of the masses at no cost to them and thereby added to the incentive to plant the trees.[43]

Eucalyptus trees were widely planted as street trees and in parks by county governments and municipalities throughout the state during the late nineteenth century. They were planted along rural roads in agricultural areas by real estate developers when these lands were divided in schemes designed to sell small farms. Individuals planted the trees to shelter and provide shade and beauty around individual farm complexes and homes. "By the end of the nineteenth century, California had been fully invaded by the eucalyptus. It could be seen almost anywhere in the state where climate permitted."[44] Although eucalyptus wood soon proved to be an inferior quality hardwood for building, it was still in

[41] Santos 1997, 28.
[42] Groenendaal 1983, 8; Santos 1997, 25.
[43] Santos 1997, 11 and 22.
[44] Ibid., 26-27.

vogue and in favor during the period when the Sutro Forest plantings were underway (1886 to 1898).

The second wave of intense interest in eucalyptus trees occurred between 1905 and 1912 and is not directly a part of the historic context for the development of the Sutro Forest. This second boom was influenced, as was the earlier wave of planting, by the problems and fears associated with disappearing forests. In 1907, the U.S. Forest Service published an influential pamphlet *The Waning Hardwood Supply and the Appalachian Forests*, written by William L. Hall, that discussed the shrinking supply of hardwood and its relationship to industrial needs, and "the miraculous eucalyptus seemed to be the solution [to the problem of diminishing timber resources] to many though Hall made no mention of it in his report."[45] In fact, Hall presciently believed that softwood, metal, and concrete would be used in place of hardwoods in the future. While the first wave of eucalyptus planting had been founded on both a genuine fascination with the botanical characteristics of the species and a cultural belief in the need for planting trees in California, the second wave was fed by speculation. The numbers of eucalyptus seedlings grown and sold were enormous: one nursery alone grew 600,000 seedlings in its first year of production in 1907, and, in 1911 eucalyptus nurseries in California produced 7,500,000 seedlings. Much of this planting resulted in eucalyptus plantations where the trees were managed as a crop and then harvested for their commercial value in as short a time as was possible (promotional literature generally specified ten years).[46] This intense interest in plantations was relatively short-lived when it became clear that the beneficial claims being promoted about eucalyptus could not be substantiated. However, Woodbridge Metcalfe, in a state bulletin on the subject, estimated that between 40,000 and 50,000 acres of eucalyptus were planted during this enthusiastic wave of speculation between 1905 and 1912.[47]

## C. Adolph Sutro's Role in Shaping the San Francisco Landscape

Adolph Sutro was born on 29 April 1830 in Prussia where his father was a prosperous cloth merchant. He left school at sixteen to work as the superintendent of his father's factory. After his father died in 1847 and the revolution that spread through Europe in 1848 "ruined the business," Sutro along with his mother, six brothers, and four sisters immigrated to the United States, arriving in New York City in August 1850 and ultimately settling in Baltimore. Sutro soon left his family and set sail for California to seek his fortune. He arrived in San Francisco on November 21, 1851 and for the next nine years he made his living first as an importer of general merchandise and then in the retail and

[45] Ibid., 30.
[46] Ibid., 34-36.
[47] Woodbridge Metcalf, *Growth of Eucalyptus in California Plantations, University of California Publications, College of Agriculture, Agricultural Experiment Station, Berkeley, California, Bulletin No. 380, November 1924* (Berkeley: University of California Printing Office, 1924), 6.

wholesale cigar and tobacco business. During this period he married and started a family.[48]

In 1859, Sutro "was attracted to the mining industry…by the bonanza [silver] strikes in Nevada" and established a small metallurgical works in San Francisco. Then in 1860 he left for Virginia City, Nevada. There he built a mill in Dayton, Nevada in 1861 and "by working over the tailing of other mills he laid the foundation of his future fortune."[49] Sutro made his fortune in the late 1860s and 1870s through the design and construction of a massive tunnel that drained and ventilated the flooded shafts of the Comstock Lode silver mines in Nevada. The construction of the Sutro Tunnel, which provided the basis for countless fortunes in silver, was also recognized as having significantly improved the working conditions for the miners and diminished risks to their health and safety. This combination of ingenuity and benevolence characterized Sutro's later work in San Francisco.[50]

After he was "squeezed" out of active management in the tunnel company, Sutro sold his stock for a profit of more than $700,000 and invested it in San Francisco real estate during a period of depression that lasted for most of the 1870s. [51] Or as Sutro explained it: "I took my money and invested in real estate when…everybody was scared and thought the city was going to the dogs. I bought every acre I could lay my hands on until I had 2200 acres in this city."[52] At one point Sutro's holdings equaled one twelfth of San Francisco's area.[53] Although Sutro purchased a significant amount of downtown property, his efforts were focused largely on acquiring the area known as the Outside Lands, located on the far western edge of the city. During the last two decades of his life, Sutro was the principal driving force behind transforming the character of this part of the city.

Sutro's largest single land acquisition was his 1880 purchase for $520,000 of a 1,200-acre parcel, the remnant of the 4,400-acre *Rancho San Miguel* that had been granted by the Mexican government to José de Jesus Noe in 1845, from a French bank whose director had committed suicide.[54] The parcel ran from the present-day UCSF Parnassus Heights campus south along Stanyan Street, up over Twin Peaks along an imaginary line running due south (aligning roughly with present-day Gennessee Avenue) to the Ocean View district, then east to Junípero Serra Boulevard, and north to Laguna Honda. The ranch contained all

[48] San Francisco Chronicle, "Sutro Goes To Rest . . . ," 9 August 1898; Eugenia Kellog Holmes, *Adolph Sutro: A Brief Story of A Brilliant Life (* San Francisco: Press of San Francisco Photo-Engraving Co., 1895), 9, 17-18, and 21.
[49] San Francisco Chronicle, "Sutro Goes To Rest . . . ," 9 August 1898.
[50] Land and Community Associates 1993 in Bradley and Corbett 1999, 104.
[51] Russ Davidson, "Adolph Sutro As Book Collector: A New Look," *California State Library Foundation Bulletin* No. 75 (Spring/Summer 2003), 7.
[52] Sutro 1894 quoted in [Chronicle Publishing Co.], *Hills of San Francisco* (San Francisco: Chronicle Publishing Co, 1959), 52.
[53] Some secondary accounts state that his holdings equaled one tenth of the city's area.
[54] Mae Silver, *Rancho San Miguel: a San Francisco Neighborhood History* ( San Francisco: Ord Street Press, 2001), 32 and 76.

four peaks of the San Miguel Hills—Mount Sutro, Twin Peaks, and Mount Davidson.[55] In 1886, Sutro began a massive tree planting effort in this 1,200-acre parcel that resulted in what soon became known as the Sutro Forest; the forested area on Mount Sutro originated with this effor. The planting for the forest is described in more detail in under "The Evolution of Mount Sutro" section. Although the origins of this planting were undoubtedly influenced by contemporary landscape ideals and forestry concerns, Sutro's ultimate plan for Sutro Forest is not known. The completion of the Twin Peaks tunnel in 1918 connected this hinterland area to the city's core and was "the spark that ignited growth" in the San Miguel rancho lands during the early twentieth century. [56] It is possible that given his engineering experience with the Sutro Tunnel that he envisioned this type of connection some thirty years earlier.[57]

The managed development of the forest ended with Sutro's death in 1898; although the protracted legal battle over his estate kept the 1,200-acre Rancho San Miguel tract and the Sutro Forest intact for over a decade. When development began in 1912, the neighborhoods that were carved out of the Sutro Forest looked very different from the rest of the city. "With no property owners to deal with and no structures, streets, or facilities to move or condemn, planners had a free reign…"[58] and the forested hillsides provided a perfect template for the implementation of the Garden City movement's tenants which called for residential parks with detached houses, villa-sized lots, landscaping, curvilinear streets, and the segregation of commercial buildings.[59] Richard Brandi noted that "St. Francis Wood and Forest Hill, the first neighborhoods to be developed on the rancho site, show the purest expression of the new ideas…cohesive design of these neighborhoods makes them appealing today and unique in San Francisco, where it has always been difficult to carry out large-scale projects."[60] Ultimately, Forest Knolls, Midtown Terrace, Sherwood Forest, Monterey Heights, Westwood Highlands, Westwood Park, Balboa Terrace, and Mount Davison Manor were developed on the former Sutro land.[61] Sutro's control of this large area and his heirs' inability to resolve their differences for so many years prevented piecemeal development and contributed inadvertently to the shaping of the neighborhoods in the western part of the city.

[55] Brandi 2003, 38.
[56] Ibid., 45.
[57] Sutro had development plans for at least the southern part of the tract. He began promoting "Lakeview," one of the earliest subdivisions in the southern part of the Outside Lands, in 1890, in the Ingleside area. The area had access to San Francisco over Ocean House Road or the San Miguel Road. Although, he developed a subdivision plan and produced drawings that showed the tree-lined streets that he proposed to build, the development mainly existed on paper. Baldwin's 1910 appraisal of the estate noted that none of the street improvements had actually been built and that there were only a few modest houses in the area. Several of the street names from Sutro's Lakeview plan are still in use today (i.e., Granada, Miramar, and Capitol) (Brandi 2003, 45; LaBounty 2003: 7)
[58] Brandi 2003, 45.
[59] Ibid., 43.
[60] Ibid., 45.
[61] Ibid., 39.

In 1881, Sutro purchased a little over 100 acres of land at Point Lobos after visiting the small frame cottage home of Samuel Tetlow that was located on a promontory overlooking the Cliff House and Seal Rocks.[62] The house had breathtaking views of the Pacific Ocean, Mount Tamalpais, and the Golden Gate, and legend has it that Sutro was so entranced with the site that he made a deposit of $1,000 (on a total sale price of $15,000) for the cottage and an adjoining 1.65 acres that very afternoon. Since the surrounding land was also for sale, Sutro was able to acquire a little over 21 acres adjacent to the cottage as well as 80 acres of shore lands bordering Fort Miley and part of the future Lincoln Park; this land included the Cliff House.[63] Between Sutro's 1881 purchase of the property and his death in 1898, he was intimately involved in the development of Sutro Heights into one of the most impressive Victorian gardens in the country, oversaw the construction of the massive Sutro Baths, had the Cliff House rebuilt as a chateau-style palace, and provided the means for the public to reach these facilities by building a railroad and providing inexpensive passenger railroad service from downtown to Point Lobos.[64]

The massive Sutro Baths structure transformed the shoreline landscape and involved the construction of two massive enormous breakwaters and an ingenious tunnel blasted through the rock to provide saltwater to six indoor saltwater swimming tanks of varying sizes, shapes, and water temperatures.[65] Above the baths were three levels of alcoves, balconies and balustrades, a restaurant on each of the three floors, galleries, an amphitheater, and a promenade. At its dedication in November 1894, the Sutro Baths could be compared to only a few buildings in the United States in terms of scale and technical achievement. Spreading over three acres, the baths were compared by one contemporary writer to "the famous ablution resorts of Titus, Caracalla Nero or Diocletion (sic)." Not only were the Baths magnificent to behold, they were lauded as breathtakingly modern and technologically sophisticated.[66]

Sutro Heights, which he opened to the public in 1885, had a full-time staff of 17—ten gardeners, a tree man, a coachman, a driver, a gatekeeper, a machinist and helper, and a road maker—to maintain the plantings, greenhouse, paths, and statuary. Sutro created a thick forest of trees interspersed by small formal and semi-formal flower beds and planting displays. The outdoor rooms created within the forest, linked by a series of paths within the tree canopy, provided the light and shelter necessary for successful plant cultivation. The terraced garden rooms were designed to feature specific plants, a piece of sculpture, or a scenic view. Each room featured an open central lawn framed by decorative plantings and was either surrounded by forest or open to the west with a view of the ocean.

[62] Tetlow, owner of the Bella Union Music Hall in San Francisco, had purchased the dwelling in November 1860 from James Butler, the first developer of the Cliff House.
[63] Land and Community Associates 1993 in Bradley and Corbett 1999, 104-105.
[64] Ibid., 104. and 143.
[65] One along the west side running 400 feet long, 20 feet deep, 25 feet wide at the top, and 75 feet wide at the base, that contains 450,000 cubic feet of rock and a second running east to west, 300 feet long, 25 feet wide at the top, 75 feet wide at the base, and 20 feet deep, that contains 300,000 cubic feet of rock.
[66] Ibid., 97-98.

Sutro opened these designed gardens to the public, provided outdoor concerts, and gave tours to school groups.[67]

During the early 1880s, Sutro became a serious book collector whose ultimate goal was to "form a collection with sufficient range and depth across different branches of human knowledge and periods of history that it might serve as the basis for a leading public research library on the Pacific Coast."[68] Within ten years, he had assembled "what apparently was the largest private library in America."[69] Sutro initially planned to locate his library at Sutro Heights, reasoning that the beauty of the site would prove inspirational to scholars. However, he abandoned this plan after several experts advised him that the Point Lobos salt air would damage his collection.[70] Instead, he decided on a 26-acre tract on the north side of Mount Sutro along Parnassus Avenue. Sutro chose this site for his library for several reasons. It was at the geographical center of the city and he believed that "as a great library is intended for…many generations to come, we should give due weight to the probable future center of the population." The site's level plateau was appropriate for construction and was protected by hills which he believed would protect the library's collections from fires. He believed the setting with Mount Sutro (or Mount Parnassus, as he called it) rising behind and "planted with a forest of pines, cypress and acacias" would "form a beautiful dark background for, and in contrast to the buildings" and that this "grandeur of nature" would inspire and spur the scholar to higher achievements.[71]

"Sutro's decision to locate the library on this parcel of land coincided with the efforts of the University of California to establish a new campus in San Francisco to house its schools of law, medicine, pharmacy, and dentistry (or what were later termed the "Affiliated Colleges"). Reasoning that both the professional schools and the library would benefit from sitting next to each other and citing such examples as Harvard, Princeton, Yale, and the Universities of Oxford, Cambridge, Paris, and Berlin, Sutro offered to deed the western half of the acreage to the University of California."[72] The Regents voted unanimously to accept Sutro's offer in October 1895. The cornerstone of the Affiliated Colleges, which formed the nucleus of today's UCSF Parnassus campus, was laid in March 1897 and the campus opened in October 1898. However, Sutro's library was never built, and the vision of a library located on the north side of Mount Sutro died with Sutro.[73]

[67] Ibid., 107 and 112-113.
[68] Davidson 2003, 3.
[69] Ibid.
[70] Ibid., 18.
[71] Adolph Sutro *Adolph Sutro's Letter to the Regents of the University of California and to the Committee of Affiliated Colleges on the Selection of a Site for the Affiliated Colleges, 5 September 1995* [San Francisco: n.p., 1895], 2-3.
[72] Davidson 2003, 19.
[73] As was the case his other properties, the battle over his estate kept the final ownership of his book collection in limbo. The books were stored in two warehouses in downtown San Francisco, and during the fire that followed the 1906 earthquake, one of the warehouses, located on Battery Street, was destroyed and with it approximately half of Sutro's collection. In 1913, Emma Sutro Merritt, who was ultimately awarded the

Sutro served one term as mayor of San Francisco in 1895 and 1896, but found politics to be unrewarding. Speaking of this period he stated: "What have I accomplished as mayor? Very little. The Mayor is little more than a figurehead…I have always been master of a situation; I have always had a number of men under my employment, and they did as I told them. I could not manage with politicians."[74] Merely one year after his return to private life, Sutro's mental capacities began deteriorating, and the court appointed his daughter Emma Sutro Merritt, one of the first women doctors to graduate from the Affiliated Colleges, as his guardian a few months before his death. Shortly before his death, Merritt took her father to live at her home on Van Ness Avenue. In a foreshadowing of the differences within his family over his estate that were to come, her siblings tried to forcibly prevent this move claiming that Sutro would be happier at his Sutro Heights home. Adolph Sutro died on 8 August 1898 at the age of 68.

National Park Service historian Paul Scolari noted that while Sutro's life ranks as one of the most notable in the various stories of immigration to the west, the expression that his wealth took in San Francisco was unique and was rooted in the wider context of wealthy philanthropists such as Carnegie, Rockefeller, and others.[75] His various projects—the Sutro Forest, Sutro Heights, the Sutro Baths, the Cliff House, and his donation of land for the nucleus of the UCSF campus—had a dramatic impact on the landscape within the western portion of the city during his lifetime and resulted in landmarks that continued to be closely linked to San Francisco's image after his death.

collection as part of the resolution of the estate, donated her father's books to the California State Library, thereby honoring his wishes for the library to be free and accessible to the public and scholars (Davidson 2003, 20).

[74] Sutro quoted in Land and Community Associates 1993 in Bradley and Corbett 1999, 126.

[75] Paul Scolari 1999 cited in Bradley and Corbett 1999, 143.

## V. EVOLUTION OF MOUNT SUTRO

The following history provides a summary of historic events and their impact on the evolving character, appearance, and features of Mount Sutro.

### A. Pre-Contact Landscape

Before the European discovery of the San Francisco Bay, the land south of the Golden Gate (from the San Francisco Peninsula to the East Bay and south to Monterey) was part of the aboriginal lands of the Ohlones, also called *Costanoans* by the Spanish. At the time of the Spanish occupation of San Francisco in the late 1700s, approximately 1,400 Ohlone, organized into a number of small, politically independent societal groups or tribes, lived in the San Francisco and San Mateo area. Groups moved annually between temporary and permanent village sites in a seasonal round of hunting, fishing, and gathering. Ethno-history suggests that small villages were maintained along the San Francisco peninsula shoreline and marshlands, and it was these activities grounded within the Ohlone's cultural beliefs and values that shaped the cultural landscape of the San Francisco peninsula. The Ohlone population and their traditional life ways—and this pre-contact cultural landscape—were altered by the Spanish colonization and the mission system.

### B. Spanish and Mexican Period

In the late eighteenth century, the Spanish expanded their empire northward from Mexico and Baja California into Alta California. In 1769, during the expedition in search of Monterey Bay, Gasper de Portolá did not recognize it and continued north to what is now San Mateo County, where members of the expedition first saw San Francisco Bay. Portolá was followed by Juan Bautista de Anza, who in 1774 established a land route from Mexico to California. Then in 1776, Anza led 240 people, over this route from Tubac, Mexico to San Francisco, in order to establish a permanent settlement.

There were three components to the Spanish settlement in San Francisco. *El Presídio de San Francisco*—located in the vicinity of today's Tennessee Hollow in what is now the Presidio—was in a protected area close to safe anchorage by the Bay; this site housed the Spanish garrison and supported the administrative and training operations. Reliable water sources, wood for fuel, and pasture land were all present at this location. To the northwest, the Spanish established the *Castillo de San Joaquín* on the bluff overlooking the Golden Gate, in the location of present-day Fort Point, to guard the entry to the Bay. Several miles southeast of the Presidio, the Spanish built *Misíon San Francisco de Asís* (now known as Mission Dolores) in a location with access to ample fresh water supplies. The Mission was protected by the Presidio and in turn supplied the garrison stationed there with food.

In 1820, the Republic of Mexico was founded and control of the Presidio transferred to Mexico. In 1834, the California missions were secularized, and the

majority of the mission lands were removed from Franciscan control. Subsequently, the Mexican government issued large land grants designed to support the cattle grazing that supplied Mexico with tallow and hides. In 1845, José de Jesus Noe received a grant, known as *Rancho San Miguel*, of over 4,400 acres (that comprised one-sixth of San Francisco).[76]

Mount Sutro is located on land that was part of the original Mission Dolores landholdings that were subsequently included within Noe's rancho grant, although its boundary cut diagonally across the northwest side of the peak. The Spanish and Mexican impact on the Mount Sutro landscape was limited to the alteration of vegetation communities by the livestock grazing. It is likely that Mount Sutro was part of the land used by the Mission to graze cattle. Similarly, Noe ran 2,000 head of cattle on his land. During this period Mount Sutro was likely covered with coastal scrub vegetation, consisting of native grasses and low to medium-sized shrubs. Historical photographs from the mid-nineteenth century do not show trees on the peak, and if there were any, such as native oaks or California bay, then they were most likely in the protected ravines on the lower slopes.[77].

### C. Start of the American Period

In 1846, California, along with the rest of the Southwest, was conquered by the United States. Like many Mexican ranchers, José de Jesus Noe found it difficult to keep his land holding intact after California became a part of the United States, and he began selling it piece-by-piece in 1848. The eastern part of the rancho was developed as early as the late 1800s, creating the residential neighborhoods of Noe Valley, Eureka Valley, and Fairmont Terrace. However, the portion of the rancho west of Twin Peaks remained open and sparsely settled by homesteaders who tended to live on scattered farms; the sandy soil was good for growing vegetables and potatoes. Settlement was hindered first by the long dispute between the City of San Francisco and the federal government over the ownership of the lands outside of the city's charter line of 1851 (lands west of Divisadero Street known collectively as the "Outside Lands") and then after 1865, following the settlement in favor of the city, by geography—its distance from the city's center and the barrier of the San Miguel Hills. San Franciscans thought of the area west of Twin Peaks as rural and remote. They would venture out on the weekends to go to the beach, and it was a popular area to pick wildflowers or to go hunting.[78]

This early American period had little if any impact on Mount Sutro. On an 1873 city guide map, the peak was not labeled and was likely not identified as a landmark or destination in the same manner as it would be by end of the nineteenth century, after the beginning of the development of the Inner Sunset on its east, north, and west sides and after Sutro had planted the forest. A broad

[76] Silver 2001, 9-10, 13-14, 40, 59, 73-76.
[77] HortScience 1999, I-1.
[78] Ibid.

swath of this 1873 map along the interior (including Mount Sutro) is simply shown as blank and was identified as the "San Miguel Rancho."[79] The land changed hands several times during the period of land speculation that followed the state's entry into the United States until Adolph Sutro purchased the 1,200-acre tract that were the remnants of the original 4,400-acre grant in 1880 from a French bank whose director had committed suicide.[80]

## D. Adolph Sutro and the Sutro Forest (1880-1898)

Adolph Sutro became a wealthy man after selling his stock in the company that had designed and constructed the massive Sutro Tunnel that drained and ventilated the flooded shafts of the Comstock Lode silver mines in Nevada. He used part of this fortune to invest in real estate in San Francisco. Although he purchased a significant amount of downtown property, Sutro focused his purchases in the city's largely undeveloped Outside Lands. Sutro's largest single acquisition was his $520,000 purchase of the 1,200-acre San Miguel Rancho parcel.[81] This parcel ran from the present-day UCSF Parnassus Heights ampus south along Stanyan Street, up over Twin Peaks along an imaginary line due south (aligning roughly with present-day Genesee Avenue) to the Ocean View district, then east to Junípero Serra Boulevard, and north to Laguna Honda. The property contained all four peaks of the San Miguel Hills—Mount Sutro, Twin Peaks, and Mount Davidson.[82]

Sutro's original plan for the rancho lands is not clear. As Richard Brandi explained in his 2003 article on this area: "Sutro was a complex man and it is not easy to uncover his motives for buying the rancho, but it does not seem to figure prominently in his scheme of things. For example, there is no record of his grazing animals or growing crops. He did not live on the rancho and did not have a house there. There are no references to his spending time on the property relaxing or entertaining as he did at his Pt. Lobos home [Sutro Heights]." During this period of his life, Sutro used his vast fortune to acquire incredible quantities of art, books, and artifacts.[83] So in one way, his decision to acquire this huge track of land all in one purchase was similar to his practice in other areas of his life.

---

[79] A. L. Bancroft & Company, *Bancroft's Official Guide Map of the City and County of San Francisco . . .* (San Francisco: A. L. Bancroft & Company, 1873); Sally B. Woodbridge, *San Francisco In Maps & Views*. (New York: Rizzoli International Publications, Inc., 2006), 80.

[80] Silver 2001, 32 and 76.

[81] Ibid..

[82] Brandi 2003, 38.

[83] For example, during an 1883 book buying spree, Sutro acquired close to 35,000 volumes, and "became known in London book circles as the 'California Book Man'" (Davidson 2003, 8), and later in the year he also purchased the major part of the Buxheim Library, the library of the Duke of Dalbert, and 86 cases of duplicate imprints from the Royal State Library in Munich (Davidson 2003, 13). Additionally, in 1883, Sutro arranged for the casting of more than 200 pieces of sculpture in Belgium, which were shipped to San Francisco in 1884 and used throughout his Sutro Heights estate (Bradley and Corbett 1999, 109). And Sutro Baths included a kind of museum, featuring a multitude of glass cases filled with stuffed birds and animals, Egyptian mummies, and other "edifying objects" including paintings and statues—all from his collections (Bradley and Corbett 1999, 123). This method of collecting was not unique to Sutro and his contemporaries (men with vast fortunes) engaged in similar practices.

The establishment of the forest at Mount Sutro was a part of Sutro's larger forest planting efforts on the 1,200-acre San Miguel Rancho parcel—in what came to be known as Sutro Forest—that began in 1886. The origins of this particular interest and of his decision to undertake this effort were undoubtedly influenced by late nineteenth-century afforestation practices that viewed planting trees as a way to address concerns over a diminishing resource and as a way to improve the land. During the 1860s, tree planting had come to be viewed as a patriotic duty throughout the country, and Sutro, along with Joaquin Miller, organized California's first Arbor Day on November 26, 1886. At this time various large-scale, tree-planting efforts were underway throughout San Francisco (although Sutro's efforts for Sutro Forest, which included tree-planting at Mount Sutro, would be the largest). Planting had begun on the Golden Gate forest in December 1871,[84] and the forest was well-established by the mid-1880s.[85] In March 1883, Major William A. Jones had authored the report ("Plan for the Cultivation of Trees Upon the Presidio Reservation") that became the plan for the Presidio Forest, and the initial tree-planting efforts at the Presidio occurred on the same 1886 Arbor Day organized by Sutro when school children planted 3,000 tree seedlings (which had been donated by Sutro) in the vicinity of Lovers Lane. On a smaller scale, George Greene Jr. had established a large eucalyptus stand on the steep slopes of what has come to be known as the Stern Grove and Pine Lake Park grove in the early 1870s.[86]

Sutro established a nursery south of the Laguna Honda reservoir, near the intersection of present-day Clarendon and 7th avenues, where he grew trees that were used for a variety of purposes—in the forest plantings, at his Sutro Heights estate, to grow seedlings to donate, and to sell. By 1889, this nursery had 250,000 trees and an extensive orchard (2,500 trees in 1896).[87] The nursery was managed by Alonzo Flanagan, who E. S. Ryder, in an 1896 newspaper article in the *San Francisco Chronicle*, called the "foster-father of the forest" because he had had "sole charge [of the nursery] from its beginning, twelve years ago."[88] Sutro employed the same type of planting strategy that had been used successfully at Golden Gate Park and that reflected contemporary forestry practices. The foundation species for the new forest were eucalyptus, Monterey cypress, and Monterey pine which he supplemented with ash, beech, and other species that, for a number of reasons, failed to get established.

[84] Beatty 2001, 7.
[85] Hall described (and defended) his planting methods in an 1886 publication (*The Development of Golden Gate Park and Particularly the Management and Thinning of its Forest Tree Plantations*) that was prepared by San Francisco's Board of Park Commissioners.
[86] Santos 1997, 20-21; Beatty 2001: 6-8; Bradley 2009, 41; Thompson 1997, 227; Bradley and Corbett 2004, Appendix A, 18.
[87] Bancroft Library, Sutro Papers, CB-465, vol. 42, Carton 2 cited in Brandi 2003: 39; Letter from Thomas U. Sweeny to Adolph Sutro, July 22, 1889, California Historical Society, Adolph Sutro Papers, MS 2115, Box, 2, Folder 21; Ryder, E. S. , "A Forest of Over a Million Trees in the Heart of San Francisco," *San Francisco Chronicle*, 18 October 1896: 1.
[88] E. S. Ryder, "A Forest of Over a Million Trees in the Heart of San Francisco." *San Francisco Chronicle* (18 October 1896).

For various reasons, the eucalyptus soon became the dominant species in the Sutro Forest. Ryder's 1896 article described a forest which contained "from 1,100,000 to 1,200,000 trees, including eucalyptus in variety, pines, cypress, acacias, ash, beech and maple. Ash and maple were less successful than the other species because they were more likely to have been eaten in their youth by cattle turned out to pasture to decrease the chances of dreaded forest fires."[89] The Eastern species set out by Sutro were also more susceptible to being shaded out by the fast-growing eucalyptus, ironically planted to protect the more delicate species from the harsh on-shore winds. The trees were planted very close together based on as assumption that this would provide the young trees with protection from the elements while the stands were getting established. The established practice was to ultimately thin out the stands to a lower density. Ryder reported in his 1896 newspaper article that "Extensive thinning has been done to benefit the trees. Growth has been so rapid that some have already attained a height of eighty-five to 100 feet, with trunks measuring a foot and a half to two feet in diameter." Whatever efforts were made to maintain and thin the forest during Sutro's lifetime, by 1910, the forest was described as being almost impenetrable in places,[90] and another major thinning operation was undertaken in 1909.

Sutro's accounts show that he hired and maintained a staff of nurserymen and laborers to plant and maintain the forest. Some of these, like Flanagan, were permanent employees, and some were undoubtedly temporary. Ryder reported that "the work of setting out the young trees from the nursery to their destination gave employment to from forty to sixty men one winter."[91] After the initial planting, the progress of the trees had to be monitored and areas replanted if needed.[92] Additionally, employees were needed to patrol the forest to look for fires which were apparently set by picnickers, hunters, and other weekend users who were already using the forest as de-facto park land.[93] This concern about the spread of fires would continue with Sutro's heirs after his death and was used as the reason to try to keep the public off the land.

In addition to tree planting, Sutro constructed a trail around the summit of Mount Sutro. No plan has yet been located of this trail but there are several

[89] Ryder's 1896. Later secondary sources provided similar descriptions but without any supporting citations. For example, the *Hills of San Francisco* reported that he planted "eucalyptus, ash, pine, and cypress trees" and that the "eculypti grew and grew, smothering out the small trees" (Chronicle Publishing Co. 1959, 52), and *The Natural World of San Francisco* stated that Sutro planted "both Monterey cypresses and pines in large numbers on Mount Sutro, but the more aggressive blue-gum eucalyptus have taken over in the decades since, and the conifers in Sutro Forest are now relatively rare" (Gilliam and Bry 1967, 95).
[90] A. S. Baldwin, *Estate of Adolph Sutro [Album]* (San Francisco: n. p. 1910), 34.
[91] Ryder 1896.
[92] Thomas Sweeny (superintendent of the overall ranch) wrote to Sutro in August 1889 that: "The forest trees in general are looking very good except the rocky ridges there are plenty of trees in the nursery to replant all that will be missing on the hills" (Letter from Thomas U. Sweeny to Adolph Sutro, 10 August 1889, California Historical Society, Adolph Sutro Papers, MS 2115, Box, 2, Folder 22).
[93] Sweeny wrote to Sutro in June 1889 that "the trees in general are looking very good but the grass is getting quite dry . . . " and that he would get the "the three men who are working in the nursery to look out for fires on Sundays . . ." (Sweeny to Sutro, 24 June 1889, California Historical Society, Adolph Sutro Papers, MS 2115, Box, 2, Folder 21).

contemporary accounts that attribute the trails here to Sutro. (A more careful review of his papers than was possible for this report may reveal more information.) One article compared them to miniature railroad routes,[94] and Ryder's 1896 article, written two years before Sutro's death, stated that "much work has been done in making walks and rustic bridges. Paths wind around the hill [Mount Sutro], affording fine distant views of the ocean, bay and city. From the summit an unbroken prospect may be enjoyed extending many miles on every side." As evidenced by the various references to them in early-1900s articles, the trails continued to exist after Sutro's death, providing the public with access onto the property and helping to develop a local constituency for Mount Sutro as a public natural area.

The origins of the overall forest planting were undoubtedly influenced by contemporary landscape values, by the contemporary afforestation movement within California, and by his personal and business interests, but Sutro's motivations and his ultimate plan for the overall forest, if he had one, are not clearly documented, and evidently were not clear even in the years immediately after his death.[95] However, the forested slopes of Mount Sutro appear to have figured prominently in his plans for a grand research library—and it is possible that the trail system may have been developed in anticipation of this library.

Sutro initially planned to locate his library at Sutro Heights, reasoning that the beauty of the site would prove inspirational to scholars. However, he abandoned this plan after several experts advised him that the Point Lobos salt air would damage his collection.[96] Instead, he decided on another inspirational site—a 26-acre tract on the north side of Mount Sutro along Parnassus Avenue. Sutro chose this site for several reasons. It was at the geographical center of the city and he believed that "as a great library is intended for…many generations to come, we should give due weight to the probable future center of the population." The site's level plateau was protected by hills which he believed would protect the library's collections from fires and was sited in front of Mount Sutro which "planted with a forest of pines, cypress and acacias" would "form a beautiful dark background for, and in contrast to, the buildings." The forested slopes of Mount Sutro also made it "possible to have lovely terraced walks under the trees for the benefits of students and visitors." Sutro believed that this "grandeur of nature" would inspire and spur the scholar to higher achievements.[97] Reasoning that the advantages of the site would apply equally to a college site, in 1895 he offered the western half of the site to the University of California for the site of the Affiliated Colleges, which was the predecessor to the UCSF Parnassus campus.

[94] "Broad paths of easy gradient, wind through the forest, cut in places through the solid rock, resembling miniature railway routes" (French 1905, 137). A 1900 article in the *San Francisco Chronicle* stated that "Good trails were paid out and graded through the hundreds of acres in this tract and Mr. Sutro formerly rode on horseback along the wooded roads"( Sexton 1900).
[95] Harold French wrote in 1905: "Whether Mayor Sutro originally intended this private forest reserve as a future pubic park or whether, as is more probable, it was planted for purely speculative purposes, is still a matter of conjecture" (French 1905, 137).
[96] Davidson 2003, 18.
[97] Sutro 1895, 2-3.

## E. Control of Mount Sutro by Sutro's Heirs (1898-1953)

Adolph Sutro died on 8 August 1898 at the age of 68. Immediately following his death, Sutro's estate was valued at $3 million but only included $473.50 in cash. His daughter Emma Sutro Merritt, who served as the executrix of his estate, called for an inventory and appraisal of the property and found the estate to be deeply in debt. In 1899, Merritt sold the Sutro railroad for the sum of $215,000 to Robert F. Morrow who renamed it the Sutter Street Cable Car line. Although this sale helped to alleviate immediate financial burdens, the estate continued to suffer from the lack of an adequate cash flow, and Merritt found that she did not have the financial resources to maintain the extensive facilities that her father had established (the second Cliff House, Sutro Baths, Sutro Heights, and the expansive Sutro Forest) at the same level as during his lifetime.[98]

Sutro's children battled in court over the terms of his will and the fate of his estate for over two decades. All of his children, except his daughter Emma Sutro Merritt, wanted to sell his vast land holdings in order to realize the wealth of his estate, but as Richard Brandi explained in his article "Farms, Fires and Forest," "[u]nder the terms of his will (created without a lawyer) Rancho San Miguel could not be sold until after the death of the last heir, at which point the proceeds could be used to fund a trust for charitable purposes. Seeing they would get nothing, the heirs sued to break this provision. The battle took twenty years to fully resolve."[99] This protracted legal battle kept the 1,200-acre Rancho San Miguel tract and the Sutro Forest intact until 1909 when a major court decision finally allowed the sale of the land, and it was another 10 years before the final distributions of his estate were made.[100]

Following the court decision in 1909 that invalidated Sutro's will and allowed his heirs to move forward with the sale of his lands, A. S. Baldwin conducted an appraisal of Sutro's properties in early 1910. The Mount Sutro area was identified as the "Forest Tract" and was appraised separately from the larger "San Miguel Ranch" tract. Baldwin noted that with the small exception of a small strip of several acres on the western slope near 5th Avenue, the entire Forest Tract (i.e. the Mount Sutro area) was heavily wooded and that the forest was "almost impenetrable" in many places. The photographs that accompanied his appraisal provide images of the extent of the forest and the character of the Mount Sutro cultural landscape in relationship to the surrounding city **(Figures 4-6, 8-10,** and **12-13)**. Baldwin described the Mount Sutro area as "one of the most picturesque tracts of land in San Francisco" and made recommendations for subdividing the land into one-half-acre to two-acre sized "villa lots" which would take advantage of the "panorama of the Ocean, the Golden Gate, the Presidio, and Golden Gate

[98] Land and Community Associates 1993 in Bradley and Corbett 1999, 127; Brandi 2003, 43-44.
[99] Brandi 2003, 43.
[100] Ibid., 45.

Park" without "denuding the hillsides of the splendid growth of trees which now exists." Baldwin valued the land at $1,800 per acre.[101]

It was at this time that the name of the peak was officially changed to Mount Sutro. During the Mexican period it had been given the name "Blue Mountain" by Frederick William Beechey, captain of the British Royal Navy ship *H.M.S. Blossom* around 1826 or 1827. It was labeled as such on the 1895 and 1898 USGS topographic quads and is referred to by this name in newspaper articles from the early 1900s. Sutro had unofficially renamed it to "Mount Parnassus." In 1910, the Sierra Club proposed renaming the peak as "Sutro Crest," but Emma Sutro Merritt "objected" to this name, and in 1911 the name Mount Sutro was made the official designation.[102]

One of Sutro's daughters, Rosa B. Morbio, received the 90 acres of the Forest Tract that included Mount Sutro (the area between Parnassus and Clarendon avenues) in the division of the estate. Another 90-acre tract that included the southern and southwestern slopes of Mount Sutro (where Forest Knolls was ultimately constructed in the late 1950s) was inherited by his daughter Clare de Choiseul, who subsequently willed the land to the Little Sisters of the Poor.[103]

Active development of whatever plans Sutro had for the forest, and more specifically for Mount Sutro, essentially ended with his death. Due to the lack of income from the estate, Merritt struggled in the years after her father's death to find the means to even minimally manage and maintain the Sutro Baths, the designed gardens at Sutro Heights, and the expansive forest. Brandi's article provided this quote from a report that Merritt prepared for the court on the estate's finances and her struggles: "She (Emma) was put to much expense in constantly watching and preventing encroachment upon said property…Small portions were rented and she found it extremely difficult to collect any rent on account of the depressed condition of business affairs and had to accept less rent."[104]

Merritt employed a caretaker who lived in a house in the vicinity of Mount Sutro whose job it was to patrol the forest, discourage trespassers, and keep a vigilant lookout for fires.[105] The threat to the forest from fires which had been an issue when Sutro was alive increased after his death when the forest density increased and maintenance decreased.[106] Harold French reported in a 1905 article in

[101] Baldwin 1910, 34-36.
[102] David July, Mount Sutro: An Electronic Periodical, 2011.
[103] Chronicle Publishing Co. 1959, 53. His son Edgar inherited the hill area south of Clarendon Avenue, and Edgar's son, Adolph Gilbert Sutro, built a three-story house, known as the La Avanzada villa, there in the 1930s. In 1948, Sutro sold La Avanzada and the surrounding land for $125,000 to the American Broadcasting Company for use as their new television station transmitter site; the Sutro Tower was constructed on this site in 1971-72 (July 2011; Hayes 1969).
[104] Brandi 2003, 44.
[105] San Francisco Chronicle 1899; French 1905; Brandi 2003, 40.
[106] A 1904 article in the San Francisco Chronicle reported that "There are fires in the forest nearly every summer Instances of fires were found in newspaper articles in 1899, 1917, 1918, 1929, 1930, 1934, 1939, 1942, and 1948 (Schneider 2009a; Brandi 2003, en28); Craig Dawson noted in a 2009 email that the area

support of finding a way to allow public access to the Mount Sutro area that "[a]t the present time the Sutro heirs strictly exclude the general public from the forests on the ground that privileges if granted, would be abused. Several dangerous fires have menaced the woods in late years which were started by careless or malicious intruders."[107] A fence marked the boundaries of Sutro's property and signs were posted to discourage trespassing ("Positively No Admittance to the Forest."[108])

However, there seems to have been a discrepancy between how the public used the property and the Sutro heirs' desire to control access. The public used the forest for hiking, camping, and hunting—and reputedly it was a common site for suicides. These uses, which had evidently been tolerated during Sutro's lifetime, continued after his death, and newspaper articles from the early 1900s described outings into the Mount Sutro woods as an option for a day out in nature that was easily accessible by public transportation.[109] The forest was described as "wilderness" where coyotes, foxes, wildcats, and other wildlife could be found.[110] Mount Sutro's location near the developed part of the city, its dramatic geography, the forest, and the access provided by the trails resulted in the creation of an identity for the landscape as a distinct place. Articles by Harold French in 1905 and 1906 argued for legal access to Mount Sutro and the rest of the forest: "Many admirers of that benevolent multi-millionaire [Sutro] maintain that he intended that this sylvan wilderness should become a public park."

The vegetation on Mount Sutro was impacted by the intermittent fires and by the thinning that was undertaken in 1909. In addition, the casual recreational use by the public likely resulted in the development of social trails throughout the landscape. A map in 1930 showed an unpaved trail or road encircling the peak (this is probably what is identified today as the "Historic Trail") and another road along the lower reaches of the south and west slopes;[111] both are visible on a 1935 aerial photograph **(Figure 14)**. The developing neighborhoods to the east, north, and west provided a distinctive contrast to Mount Sutro's forested slopes, and the extension of Clarendon Avenue west to 7th Avenue in 1932 created a definitive boundary or edge along the south side; until then the forest on the peak's south side extended unbroken into the larger Sutro Forest. The most dramatic impact to the cultural landscape was the logging which occurred in the early 1930s. This operation ended in 1934 after a fire burned ten acres that required 400 firemen to extinguish.[112] An aerial photograph taken in 1935 shows the extent of this operation and how all trees were clear-cut across the entire

behind the Chancellor's house burned in the 1940s or 1950s; and there were likely other undocumented fires.

[107] French 1905, 137.

[108] Ibid., 136.

[109] An 1896 newspaper article by E. S. Ryder reported that "Virtually it is closed; that is, a right is not yet given to enter. But our public-spirited millionaire does not refuse admittance to the well-behaved, who can be trusted not to start a fire and has declared his intention to donate a part as a public picnic ground, especially for the benefit of the school children."

[110] Sexton 1900; Chandler 1902; San Francisco Chronicle 1904; French 1905 and 1906

[111] United Railways 1930.

[112] Brandi 2003, 40 from *San Francisco Chronicle* 10-15-1934, p. 15.

south half of the landscape. A subsequent Works Progress Administration (WPA) project sacked and warehoused the left-over wood from this logging operation to supply "indigent families with stove wood; as part of this project "certain areas previously logged" were cleaned and burned.[113]

## F. UCSF Period (1953-present)

In 1953, UCSF purchased Rosa B. Morbio's 90-acre tract.[114] This purchase began a period of accelerated development within the Mount Sutro Cultural Landscape Study Area that has resulted in the addition of new buildings, the reduction of the overall forested area, and a redefinition of its boundaries.[115]

The first noticeable alteration of Mount Sutro occurred with the construction of the northern half of the Medical Center Way alignment from Parnassus Avenue to the vicinity of the present-day Woods Lot, between 1948 and 1955. A rectangular section of the forest (roughly corresponding to the footprint of the present-day Woods Lot) was removed and a University-related facility was added on the east slope at the end of the new road. A smaller area was cleared on the uphill slope at the west end of the road to make way for a University-related water treatment facility.[116]

The summit was altered in 1954 when UCSF leased four acres to the federal government, which then constructed the control center for Nike Battery SF-89 as part of the Bay Area's Nike missile defense system. Most Nike batteries located around the Bay Area included a launcher area (where the missiles were stored in underground rooms, brought up on elevators, and launched) and a separate control center with a radar complex, which because of the requirement for an unobstructed view of the launch area, was usually located at a high elevation. The launch area for SF-89 was located at the Presidio of San Francisco in the vicinity of Battery Caulfield, and the control center was located atop Mount Sutro.[117] As part of the construction of the control center, a road was laid out from Clarendon Avenue to the summit, the forest at the summit and a portion of the south slope were clear-cut, and the Nike structures were added to the summit. Nike Battery SF-89 was active from 1955 through 1963. After the nationwide Nike system was decommissioned in 1974, this site reverted back to UCSF which used the leftover buildings for various uses. The Nike building site was

[113] William Mooser, Jr., *Report on Progress of the Works Program in San Francisco* ([San Francisco]: Works Progress Administration. January 1938), 80 and 90.
[114] UCSF Campus Planning, 2010b, 5. The book *Hills of San Francisco* lists the purchase as being in 1947 (Chronicle Publishing Co. 1959, 53).
[115] In 1957, the City and County of San Francisco purchased about 16 acres of the former Sutro Forest land: a 12-acre parcel located between the east side of the UCSF purchase and Stanyan Street and an additional 4-acre parcel south of Clarendon Avenue; these two disconnected parcels became part of the Interior Greenbelt (Zito 2011, D-1).
[116] Pacific Aerials Surveys 1948 and 1955.
[117] There were three other radar complexes in the Bay area: on Wolf Ridge at Fort Cronkite, at Diablo Ridge, and on Angel Island.

cleared and all of the buildings on the summit were removed between 1972 and 1977, and the summit area was gradually invaded by woody shrubs.[118]

Medical Center Way was extended south to Johnstone Drive between 1958 and 1961 as part of the construction of the Aldea San Miguel Married Student Housing Complex. The extension of Medical Center Way required cut-and-fill alterations to the natural topography and the completed alignment bisected area within the Mount Sutro Cultural Landscape Study Area. The construction of this ca. 1961 alignment removed a portion of the Sutro-era trail, and the University appears to have rebuilt a portion of this trail (today's Fairy Gate Trail) that is located below (east) of the road bed.[119]

The southern side of the Mount Sutro Cultural Landscape Study Area was dramatically altered by the construction of the Aldea complex between 1957 and 1961. The University hired the firm of Clark & Beuttler in association with George Rockrise to construct 150 units of married students' housing. Landscape architect Lawrence Halprin was responsible for siting the buildings and for the landscape design. The 25.5-acre site was cleared and re-graded, and eight, two-story buildings connected by a system of sidewalks and steps and three roads (Johnstone Drive, Behr Avenue, and Adolph Sutro Court) added within the steeply sloping site. In 1966, University House, the Chancellor's residence, was added to the east side of Johnstone Drive. The design for the residence took advantage of the natural topography; it was sited at the edge of a prominent natural rock outcropping, above the area that is locally referred to as "Ishi's Cave," that overlooked the Stanyan Canyon so that the house had a panoramic view of the City and the Bay. George Rockrise was the architect and Royston, Hanamoto, Mayes, and Beck were the landscape architects.[120]

More isolated alterations occurred during the 1960s as part of the expansion of the UCSF research facilities into Mount Sutro's forested area. The Woods Building (100 Medical Center Way) was built along the east side of Medical Center Way in 1962. The Surge Building (99 Medical Center Way) was added just south of the Woods Building complex in 1966; the associated parking lot resulted in the removal of an additional portion of the forest (corresponding to the footprint of the lot).[121]

In the late 1950s and early 1960s, the topography and the forest on the western and southwestern slopes of Mount Sutro were altered by the development of Forest Knolls. (Although outside of the boundaries of the land owned by the University, this area was historically part of the portion of the Sutro Forest located on and around Mount Sutro.) By 1958, the forest had been clear-cut and graded

[118] Erwin N. Thompson, *Historic Resource Study: Seacoast Fortifications San Francisco Harbor, Golden Gate National Recreation Area, California* (Denver: Denver Service Center, Historic Preservation Team, National Park Service, 1979), 411; The Military Standard 2011; Jef Poskanzer 2011; Pacific Aerial Surveys 1955, 1958, 1961, 1969, 9172, and 1975; HortScience 1999, I-4.
[119] Pacific Aerial Surveys 1958 and 1961.
[120] Carey & Co., *Draft UCSF Historic Resources Survey, San Francisco, California* (31 July 2010), 24-27.
[121] Pacific Aerial Surveys 1948, 1955, 1961, and 1968; Dawson 201; Carey & Co. 2003, 28-29.

for this housing development, and construction of about half of the houses was underway in 1961. Christopher and Crestmont drives, which were laid out as part of the Forest Knolls development, created a new perceived boundary to the forested area associated with Mount Sutro,[122] although some remnants of the forest remained in Forest Knolls, on the slopes west of Crestmont and Warren Drives.

In 1976, The Regents of the University of California designated the 58 acres of forest that lay within the boundaries of the UCSF property as the Mount Sutro Open Space Reserve (Reserve) and designated this area as a permanent open space accessible to the public.[123] This designation was a formal recognition of what had been an informal but longstanding public identification of Mount Sutro as a distinctive open space and naturalistic landscape within the city and of its use for recreation throughout the twentieth century. In 1996, UCSF prepared a Long Range Development Plan (LRDP) to guide the physical development of the campus. The LRDP updated the boundaries of the Reserve to reflect the results of a survey which found that area contained an additional three acres, for a total of 61 acres. The LRDP reaffirmed UCSF's commitment to maintaining the Reserve as permanent open space and included a proposal to investigate an appropriate maintenance and restoration program for the trees, other vegetation, and the trail network within its boundaries. To fulfill this proposal, the Mount Sutro Open Space Reserve Management Plan (Management Plan) was prepared in 2001 to provide a framework for future management activities. This management plan surveyed the conditions of the forest and made recommendations to address its long-term health. The location and condition of the trails were also addressed within the management plan. In 2006, a group of local volunteers organized themselves into the Sutro Stewards and began an ongoing program of trail restoration activities. The historical research and physical surveys that have been undertaken as part of their work have led to a rediscovery of trails that had fallen out of use and to a broader understanding of the overall trail system.

The forested area between the eastern boundary of the University-owned land and the residences along the west side of Stanyan Street historically was part of the Sutro Forest but is now owned by the City and County of San Francisco. This area is called the Interior Greenbelt and is managed as part of the Department of Parks and Recreation's Natural Areas Program. An additional section of the Interior Greenbelt is located on the south side of Clarendon Avenue in the vicinity of the Sutro Tower.

## VI. EXISTING CONDITIONS

Within the framework for cultural resources analysis, Mount Sutro can best be described as a cultural landscape. Cultural landscapes are defined as geographic areas shaped by human activity; they can result from a conscious design or plan, or evolve as a byproduct or result of people's activities; and they

[122] Pacific Aerial Surveys 1955, 1958, 1961, and 1968.
[123] UCSF Campus Planning 2010b, 1.

may be associated with a historic event, activity, or person or exhibit other cultural or aesthetic values.[124] There are four general types of cultural landscapes: historic sites, historic designed landscapes, historic vernacular landscapes, and ethnographic landscapes.[125] These types are not mutually exclusive and Mount Sutro has characteristics of both a designed landscape[126] and a vernacular landscape.[127] The California Register does not provide specific guidance for describing cultural landscapes. However, the California Register was consciously designed on the model of the National Register (the two programs are extremely similar, although there are areas in which these programs differ, and guidance provided in National Register and National Park Service publications were used in describing the existing conditions on Mount Sutro.[128]

As described in National Register bulletins on cultural landscapes, both the processes that helped to form the landscape and its individual components are critical to the understanding of a cultural landscape. The key processes to the formation of a cultural landscape include land uses and activities, patterns of spatial organization, responses to the natural environment, and cultural traditions. The individual components of a cultural landscape include groupings of features within a larger landscape, circulation-related features, the various types of boundary demarcations, vegetation features, buildings and structures, archaeological resources, and small-scale elements. Individual features do not exist in isolation within a cultural landscape, but rather in relationship to the landscape as a whole, and it is the arrangement and the interrelationship of these character-defining features—as they existed during the period of significance—that is most critical to understand in evaluating the significance of a cultural landscape. The importance of individual features to the development process may vary from landscape to landscape, and some features may be more important than others.[129]

For Mount Sutro, the forest itself (its primary vegetation feature), the presence of trails (its primary circulation feature), the natural topographic characteristics of the site, and the recreational land use are the character-defining features that have remained consistent since at least the late 1880s. The following description

[124] National Parks Service, Secretary of the Interior's Standard for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes (1996), page 4.
[125] NPS 1996, 4.
[126] A designed landscape is one that was consciously designed or laid out by a landscape architect, master gardener, architect, engineer, or horticulturist according to design principles. The landscape may be associated with a significant person, trend, or event in landscape architecture or may illustrate an important development in the theory and practice of landscape architecture. Aesthetic values tend to play a significant role in designed landscapes (NPS 1996, 5).
[127] A vernacular landscape has evolved through use by the people whose activities or occupancy shaped it, and as a result function plays a significant role in vernacular landscapes (NPS 1996, 5).
[128] Publications that were reviewed for guidance including National Register Bulletin 18: How to Evaluate and Nominate Historic Designed Landscapes, National Register Bulletin 30: How to Evaluate and Document Rural Historic Landscapes, and The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes.
[129] NPS, National Register Bulletin 30: How to Evaluate and Document Rural Historic Landscapes (1999), 3-6.

provides a discussion of the evolution of these character-defining features along with the other cultural landscape features that are present today. A brief definition of the individual feature is given, followed by a description of the existing conditions, and an analysis of the origins and evolution this category of feature.

## A. Land Uses

Land uses are the major human forces that shape and organize a cultural landscape.[130]

Land uses within the Reserve include the open space that provides natural habitat and recreational opportunities and the developed areas with University-related residential and academic land uses.

Additionally, the lower slopes on Mount Sutro's west and south sides are developed and have residential land uses; the Interior Greenbelt area bordering the eastern boundary of the Reserve provides natural habitat and recreational opportunities similar to those within the Reserve. These areas are located outside of the boundaries of the Reserve but were historically part of Sutro's land at Mount Sutro.

As noted in early twentieth-century accounts of the Mount Sutro area and confirmed by secondary sources (such as Brandi 2003), Adolph Sutro did not explicitly state his ultimate intent for the land use within the Sutro Forest. When initially planted, the forested area around Mount Sutro was private land but was apparently informally used by the public for recreational land uses, including hiking, picnicking, and hunting. Sutro apparently constructed a trail system around the peak, and the letter he wrote to the University Regents in 1895, with the offer to donate the western half of a tract along Parnassus Avenue for the Affiliated Colleges, seems to indicate that he intended this trail system and the forest peak to have some type of public access in association with the college and his future library (the eastern half of the Parnassus Avenue tract was to be the site of his library). After Sutro's death, the forest at Mount Sutro remained nominally private property, with fences defining the boundary, "no trespassing" signs, and a caretaker who lived on the site and who patrolled the area, but nonetheless continued to be used by the public. Today, the recreational and natural habitat land uses within the Reserve continue to provide a strong link to the historic land uses at Mount Sutro.

## B. Natural Features

The location of major natural features (such as mountains, prairies, rivers, lakes, forests, and grasslands), climate, soils, and topography can influence both the location and organization of features within cultural landscapes.[131]

[130] Ibid., 4.
[131] Ibid., 4.

Mount Sutro is the northernmost peak of the San Miguel range and its summit is 908 feet above sea level. The soils throughout the Reserve are relatively shallow and not rich in nutrients. Numerous outcrops of the underlying Franciscan formation cherts occur throughout the Reserve. Other than the summit area, steep slopes characterize the Reserve with over 60 percent of the Mount Sutro having slopes in excess of 30 percent.[132]

The steep slopes and exposed rock outcroppings present today are consistent with those encountered by Adolph Sutro when he undertook the planting of the forest. This topography influenced the layout of the trails that Sutro constructed, and along with the growth of the forest, contributed to the perception of this area as a distinct area separate from the surrounding city. **Figures 37**, **38** and **47**-**49** provide photographs of examples of the topography and rock outcrops. The height and topography of the peak allowed for provided panoramic views in all directions. After the trees were planted on Mount Sutro these views were often blocked or partially blocked by vegetation. **Figure 50** provides an example of the type of view that is available from the trails within the Reserve.

Stanyan Canyon (also known as Woodland Canyon) is located on the east side of the peak and Woodland Creek flows through this canyon. The steep terrain of this geographical feature, which prevented the subdivision of this land and the connection of Stanyan Street to the east with Woodland and Edgewood avenues to the north, has contributed to the lack of development in this area.

Stanyan Canyon, along with the rocky ledges, steep terrain, and summit, were consistently mentioned as distinct geographical features in early twentieth-century descriptions of the Mount Sutro area. Changes that have occurred to these topographic characteristics include the ongoing failure of rock outcroppings where tree roots have penetrated and grown within the cracks within the chert; the leveling of the summit and the cut-and-fill to build the access road for the Nike site in 1954-55; the loss of native soil when the Nike site was essentially scraped in the mid-1970s and the Nike structures were removed; and the grading that accompanied the construction of the University-related features (i.e., Medical Center Way, the Aldea complex, the Surge and Woods buildings and their related parking lots, the Chancellor's residence, and the water tanks and water treatment facility.) Additionally, the lower slopes on Mount Sutro's west and south sides were dramatically altered in the late-1950s by the grading for the Forest Knolls neighborhood; this portion of Mount Sutro is located outside of the boundaries of the Reserve.

Mount Sutro is located within three miles of the Pacific Ocean and like the rest of the city its proximity to the coast affects the climate. San Francisco's climate is generally classified as Mediterranean in character with cool, wet winters and cool summers with frequent fog or wind. Rainfall averages about 22 inches per year

[132] HortScience et. al. 1999, IV-7 and 8; EDAW 2001, 17 and 18.

and occurs consistently only in the winter and early spring.[133] This concentration of rainfall during the winter months when combined with the steep topography promotes runoff and erosion hazards.

The site's coastal climate, combined with the sun exposure, the predominant direction of the wind, and the location of soils, results in three different microclimates. These microclimates explain some of the variation of the vegetation within the Reserve, the location of the remnant native plant communities, and the condition of the vegetation. The north-facing slopes are less exposed to the sun, are exposed to predominantly northwest winds from the ocean, and retain the highest levels of humidity and moisture in the soil. Eucalyptus and other forest vegetation tend to be the most vigorous on the north and east facing slopes. Conversely, slopes facing south tend to be the warmest and driest. Additionally the west-facing slopes are also dry, but here the condition is as much from wind exposure as from sun exposure.[134] It seems unlikely that Sutro took into account these microclimatic variations when he planted the forest, and the variations in the locations of vegetation, as a response to the microclimates, are related to the plant communities' adaptations to the site rather than to a conscious design.

### C. Boundary Demarcations

There can be several types of boundaries on a property. These include legal and visual boundaries, those related to the entire property, and those that define separate areas within the property. Boundary demarcations delineate areas of ownership and land use, such as an entire farmstead or a city lot. They also separate smaller areas having special functions, such as a fenced field or an enclosed corral. Fences, walls, tree lines, hedge rows, drainage or irrigation ditches, roadways, creeks, and rivers commonly marked historic boundaries.[135] Within the Reserve, these boundaries are closely linked to the spatial organization of the cultural landscape.

The 61 acres that are within the legal boundaries of the Reserve are shown on **Figure 2**.

The Mount Sutro Cultural Landscape Study Area consists of the 61-acre Reserve that is owned and managed by UCSF and the 12-acre portion of the Interior Greenbelt that is adjacent to the east side of the Reserve. The Interior Greenbelt is owned by the City and County of San Francisco and is managed by the San Francisco Recreation and Park Department. Although there is a legal boundary between these two areas, there is no visible boundary and the cultural landscape within the two is basically indistinguishable. Both the Reserve and this portion of the Interior Greenbelt were part of the original Sutro Forest planting.

[133] EBMUD, *Plants And Landscapes For Summer-Dry Climates of the San Francisco Bay Region* (Oakland, CA: EBMUD, 2004), 3, 14-15.
[134] EDAW 2001, 15.
[135] NPS 1999, 5.

Initially, the difference between the appearance of the forested Mount Sutro and the open land that surrounded it provided a visual or perceived boundary around the Mount Sutro cultural landscape, and this boundary was reinforced by fencing that was located along the property's edge. See **Figures 4, 5, 8,** and **10** for examples of the difference in appearance between the forest and the surrounding open land and examples of fencing that formed the perceived boundary around the Mount Sutro cultural landscape in the early twentieth century.

Today the visual boundaries or edges of the Reserve (as a remaining part of the Mount Sutro cultural landscape) are defined by circulation features and urban land uses that have developed around Mount Sutro since the forest was originally planted in the late nineteenth century. See **Figures 4-13** for a comparison between the historical and the present-day views; see **Figures 14**-1**9** for aerial views that illustrate the evolution of this changing visual boundary; and see **Figures 20**-**25** for examples of the visual edge around the Reserve.

The UCSF campus along Parnassus Avenue is located just north of the Reserve. Two streets, Koret Way and Medical Center Way, and their related retaining walls define the visual edge along the north side of the Reserve.

Residences along the west side of Edgewood Avenue, with fences or walls along this shared boundary, and the Interior Greenbelt are located on the east side of the Reserve. Visually there is no distinction between the forest in the University-owned Reserve and that in the City-owned Interior Greenbelt, and in fact the Interior Greenbelt area, which extends east to Stanyan Street, is a part of the original Sutro Forest (historical accounts describe Stanyan Street as the eastern edge of the Sutro Forest).

Residential land uses border the south side of the Reserve. Clarendon Avenue, Christopher Drive, and a short stretch of Crestmont Drive define this edge along the south side of the Reserve. The UCSF Aldea San Miguel Housing Complex and the Chancellor's residence are located on the south side of the Reserve, and this area is not a part of the legal boundaries of the Reserve. The roads, parking lots, and other hardscape features define the visual edge between the forest and the main core of the Aldea housing area. However, the forest blends seamlessly around the Chancellor's residence and the one Aldea housing unit (50 Johnstone Drive) located on the north side of Johnstone Drive.

Crestmont Drive continues along the west side of the Reserve and defines the visual edge between the forest and the Forest Knolls neighborhood. The Kirkham Heights apartment buildings are located next to the northwest corner of the Reserve. The legal boundary for the Reserve is located several feet from the edge of Crestmont Drive, and ornamental trees and shrubs have been planted in this narrow strip of City-owned land immediately adjacent to Crestmont Drive.

## D. Spatial Organization

Spatial organization refers to the three-dimensional organization and the patterns of space in a landscape and is analogous to the arrangement of rooms in a house. The organization of features in the landscape defines and creates spaces and is often closely related to land use. The functional and visual relationships between these spaces within the landscape are integral to the historical character of a property.[136]

The trees planted by Sutro formed a contiguous forest throughout Mount Sutro, and the experience within the landscape was one of open space defined by the natural topography and stands of trees. There would have been both a sense of expansiveness due to the uninterrupted open space (i.e. lack of buildings and roads) and enclosure created by the towering trees.

Today, Medical Center Way and Johnstone Drive cut through the forest and essentially divide the landscape into two separate areas. Additionally there are pockets of the forest that have been removed by the addition of UCSF buildings and their associated infrastructure. These pockets include two areas on the northeast edge of the Reserve where the Surge and Woods buildings are located and a large area near the southeast corner of the Reserve next to Clarendon Avenue where the Aldea housing complex and the Chancellor's residence are located. The land around these buildings and their associated infrastructure have been excluded from the legal boundary of the Reserve. Outside of the direct sightlines of the Medical Center Way/Johnstone Drive alignment and the pockets of built environment, the open space is covered with a contiguous forest and subareas created by the topography (i.e. the summit, Stanyan Canyon, etc.) are still the dominant spatial features within the Reserve.

## E. Buildings and Structures

Cultural landscapes often contain various types of buildings and structures that serve the human needs related to the occupation and use of the land. The distinction between the two is generally defined as buildings are designed to shelter human activity, and structures are designed for functions other than shelter.[137]

There are only a limited number of structures located within the Reserve. These include a small structure on the north side of Nike Road, a water tank located south of the summit, and a water treatment facility and water tanks located off of Medical Center Way in the area west of the Woods Parking Lot. The building on Nike Road may be a remnant of the Nike site, and the water tanks and treatment facility were added by the University between 1958 and 1961.

[136] NPS 1996, 15.
[137] NPS 1996, 16; NPS 1999, 6.

The Aldea housing complex, the Chancellor's residence (66 Johnstone Drive), the Woods Building (100 Medical Center Way), and the Surge Building (90 Medical Center Way) are also located within the Mount Sutro Cultural Landscape Study Area. However, the land around these buildings and their associated infrastructure has been excluded from the legal boundary of the Reserve.

Additionally, the lower slopes on Mount Sutro's west and south sides now contain houses that are a part of the Forest Knolls neighborhood which was carved out of the Mount Sutro forest in the late-1950s. This residential neighborhood, located outside of the boundaries of the Reserve (and the Mount Sutro Cultural Landscape Study Area).

None of these UCSF or Forest Knolls neighborhhood structures and buildings are associated with Sutro's development of Mount Sutro.

## F. Circulation Features

Examples of circulation features include roads, parkways, drives, trails, walks, paths, parking areas, and canals. Such features may occur individually or may be linked to form networks or systems. The character of circulation features is defined by factors such as alignment, width, surface and edge treatment, grade, materials, and infrastructure.[138]

Circulation features in the Reserve are generally associated with the present-day recreational use of the Reserve or with UCSF. Additionally, there is one road associated with the prior use of the site by the Nike missile program.

### *Vehicular Routes*

Vehicular circulation features within the Reserve include Medical Center Way, Johnstone Drive, Nike Road, and two short access routes to the water tanks.

- Medical Center Way and Johnstone Drive provide vehicular access between Parnassus Avenue and the main core of the UCSF campus to the north and Clarendon Avenue to the south. Their combined alignment divides the Reserve into two areas. Medical Center Way was added by the University between 1948 and 1955 and originally began at Parnassus Avenue and ended in the vicinity of the present-day Woods Lot; it was extended south to Johnstone Drive around 1961 when this road was built as part of the Aldea housing complex.

- Nike Road begins at the west end of Behr Avenue and ends near the summit. This road was built during 1954-55 as part of the Nike SF-89-C site and provided access from Clarendon Avenue to the summit (the location of SF-89-C). Part of the road's original

[138] NPS 1996, 15.

alignment (between Clarendon Avenue and its present-day beginning) was removed when the Aldea housing complex was built in 1961.

- A short paved road provides access to the water tanks and water treatment facility located on the west side of Medical Center Way in the vicinity of the Woods Lot. Based on a review of aerial photographs the road was added between 1948 and 1955.

- An unpaved road provides access from the Nike Road to the water tank located just south of the summit; this road was added between 1958 and 1961.

None of these roads are associated with Sutro's development of Mount Sutro. **Figures 26**-**30** provide photographs of these roads.

### *Pedestrian Routes*

There are several pedestrian circulation routes within the Reserve that are University-related. These include the following:

- A path along the east/north side of Medical Center Way provides a pedestrian route from the Aldea housing complex and the Surge and Woods buildings and parking lots to the main UCSF complex. It is an informal unpaved path between the Surge Lot area and the bus stop near the EH&S building and is paved with what resemble asphalt shingles between the Woods Lot and Johnstone Drive.

- Stairs and a paved path are located on the hillside west of the Surge Lot and provide access between this parking lot and the main campus area.

### *Hiking Trails*

An unpaved trail system provides access throughout the Reserve and connects to surrounding streets at its periphery. The trails located west of Medical Center Way include the following:

- The upper portion of the Historic Trail provides access around the perimeter of the west and north sides of the Reserve. It intersects with the South Ridge Trail (on the south side of the Reserve) and with Medical Center Way near the Woods Lot. The trailhead at Medical Center Way is across the street from the entrance to the lower portion of the Historic Trail (i.e., the portion of the trail between Medical Center Way and Stanyan Street).

- The South Ridge Trail provides access within the southwest portion of the Reserve. Its north end intersects with the Nike Road and its south end begins at Christopher Drive.

- The West Ridge Trail provides access from Crestmont Drive on the west side of the Reserve straight up the ridge to the summit and is maintained for emergency fire hose access by UCSF. This trail intersects the Historic Trail and ends at Nike Road near the summit.

- The North Ridge Trail provides access between Medical Center Way and the summit along the north side of Mount Sutro. The trailhead at Medical Center Way is directly across the street from the entrance to the Fairy Gates Trail.

- The East Ridge Trail provides access between Johnstone Drive and the summit along the eastern ridge of Mount Sutro.

- The Mystery Trail connects the North Ridge and East Ridge trails and runs along the north side of Mount Sutro.

The trails located east of Medical Center Way include the following:

- The lower portion of Historic Trail runs parallel to and below Medical Center Way for a short way crossing Edgewood Trail and head east through the city-owned Interior Greenbelt to the Stanyan Street trailhead.

- The Edgewood Trail originates at Edgewood Avenue where it leads south through forest that is part of the Interior Greenbelt toward Woodland Creek; from there it climbs up through the canyon crossing the lower Historic Trail to intersect with the Fairy Gates Trail.

- The west trailhead of the Fairy Gates Trail is located directly across Medical Center Way from the North Ridge Trailhead. This trail runs parallel to and below Medical Center Way to connect to its east trailhead near the Chancellor's residence.

- The Belgrave Trail begins at the driveway to the Chancellor's residence and continues down the steep ridge on the southeast side of the house, into the Interior Greenbelt, and ends at the trailhead at Belgrave Avenue.

- A narrow trail, identified as the Ishi Loop on Figure 13 in the 2001 EDAW report, branches off the Belgrave Trail and leads to the rock outcrops northeast of the Chancellor's residence.

- The East Boundary Trail connects the Surge Lot and Farnsworth Lane and runs immediately next to the Reserve's east boundary. A

narrow trail (the Farnsworth Trail) branches off the East Boundary Trail at its midpoint and leads down to Medical Center Way.

**Figures 29-49** provides images of these trails. **Figure 52** shows the location of all of the trails except the Ishi Loop (which is not labeled on the map in this figure). The trails vary in width but are generally two to three feet wide, and all are unpaved.

The Historic and Fairy Gates trails have constructed alignments. These two trails have been deliberately laid out in relationship to the existing topography to create an alignment that progresses at a fairly stable elevation through the natural terrain. The bench construction of the trailbeds was cut into the hillside and used the resulting fill to create a level bed for walking. At certain locations the sides of the trail bed (bench) are built up and reinforced with low drystone retaining walls or edging; culverts have also been added at places to prevent erosion of the trailbed.

The North, East, West, and South Ridge trails, the Mystery Trail, the Edgewood Trail, and the Ishi Trail developed as social trails where worn paths developed over time from use (i.e., there was no grading). These paths tend to have steeper alignment up the hillsides than the two constructed trails; this has made them more prone to erosion damage and in some locations less safe.

Contemporary newspaper and journal articles credited Adolph Sutro with the construction of a circulation system of graded paths through the forest he planted at Mount Sutro.[139] The exact location of any Sutro-constructed paths is not known. However it seems likely that the present-day Historic and Fairy Gates trail alignments were either built by Sutro or were on the property prior to his acquisition of the Rancho San Miguel tract in 1880. The characteristics of these trails show that they were deliberately planned and laid out and required considerable effort to construct. These two trails were originally part of one alignment which was severed by the construction of Medical Center Way in the early 1960s.

Additionally, this constructed trail system appears to have continued down through the forested canyon, now part of the Interior Greenbelt, to a trailhead on Stanyan Street at 17th Street. Sometime after the City purchased this portion of

[139] Sutro mentioned the possibility of having "lovely terraced walks under the trees for the benefits of students and visitors" on Mount Sutro in his 1895 letter to the University Regents regarding the donation of land for the Affiliated Colleges on Parnassus Avenue (Sutro 1895).

An 1896 article in the *San Francisco Chronicle*, written two years before Sutro's death, stated that "much work has been done in making walks and rustic bridges. Paths wind around the hill, affording fine distant views of the ocean, bay and city. From the summit an unbroken prospect may be enjoyed extending many miles on every side" (Ryder 1896).

A 1900 article in the *San Francisco Chronicle* stated that "Good trails were paid out and graded through the hundreds of acres in this tract and Mr. Sutro formerly rode on horseback along the wooded roads"(Sexton 1900).

A 1905 article in the *Overland Monthly* described "Broad paths of easy gradient, wind through the forest, cut in places through the solid rock, resembling miniature railway routes" (French 1905, 137).

the forest, between the eastern edge of the Reserve and Stanyan Street, residents blocked off the trailhead at Stanyan Street, and this portion of the trail was no longer maintained or used. A group of volunteers known as the Sutro Stewards recently reconstructed the Interior Greenbelt portion of the trail (now sometimes called the Lower Historic Trail) in partnership with the San Francisco Recreation and Park Department. The trail reopened in June 2011, and its western trailhead now connects to the Edgewood Trail just inside the Reserve's boundary.[140]

Based on a review of historical maps and aerial photographs, other paths and unpaved roads were added and subsequently abandoned within the Mount Sutro Cultural Landscape Study Area based on land use and activities on the property. In a 1935 aerial photograph, unpaved paths or roads are clearly visible on the recently logged slopes and continue to be visible in aerial photographs through the late-1950s. By the 1960s, the trees' canopies block views of the ground in aerial photographs.[141]

According to the 2001 EDAW report, the trails were first informally mapped in the 1970s, and at that time there was a "fairly extensive unimproved dirt trail system" which was maintained by UCSF "for a period of time" until maintenance funding became unavailable. Beginning in 1999, the University renewed the trail maintenance effort on "most of the trails." Unpaved trails are ephemeral features, and during the period when UCSF suspended maintenance, "a number of the trails became overgrown with poison oak, blackberry, and other low-growing plants and were covered up with forest debris and in some cases fallen trees to the point that they were not readily apparent and impassable."[142]

Around 2005, a group of local volunteers organized themselves into the Sutro Stewards and began an ongoing program of trail restoration activities. The historical research and physical surveys that have been undertaken as part of their work have led to a rediscovery of trails that had fallen out of use and to a broader understanding of the overall trail system. According to Craig Dawson, the Executive Director of the Sutro Stewards, when the group began their work the four ridge trails, the Mystery Trail, the Fairy Gates Trail, and the Edgewood Trail were visible. The Stewards have undertaken repair and restoration work on all of these trails. Some changes were made for safety and erosion control (the upper North Ridge, East Ridge, and Edgewood trails) and to provide better links between the trails (a new section of the North Ridge Trail was added at its lower end at Medical Center Way as a connector to the Fairy Gates and Edgewood trails). Their work during 2005 and 2006 led to the rediscovery and repair of the Historic Trail which had been "lost" to the accumulation of forest debris and eroded soil.[143]

[140] United Railways 1930; Dawson 2011; Zito 2011, D-1; Pease Press Cartography 2011.
[141] United Railways 1930; Pacific Aerial Surveys 1935, 1938, 1948, 1955, 1958, and 1961; Dan Schneider 2011; Dawson 2011.
[142] EDAW 2001, 28.
[143] Dawson 2011.

## G. Vegetation Features

Vegetation features may be individual plants (such as a specimen tree) or groups of plants and include indigenous, naturalized, and introduced species.[144]

Within the Reserve boundaries there are three main types of vegetation features: the forest, several small native plant communities, and the Rotary Meadow, a native plant demonstration area at the summit. The existing conditions photographs in the Appendix **(Figures 26-50)** provide various views of the vegetation within the Reserve.

With the exception of the summit, the Reserve is covered by a dense stand of trees that is dominated (approximately 82 percent) by blue gum eucalyptus (*Eucalyptus globulus*). The predominance of eucalyptus reflects the forest's origins from the trees planted by Adolph Sutro in the late 1880s and 1890s as part of the Sutro Forest. While some of the original trees from the Sutro planting remain, the current composition of the forest reflects the regeneration process of the original stand that has occurred over the past 120 years as impacted by logging[145] and fires[146], by past maintenance practices such as logging that has resulted in stump sprouting, by the spread of exotic species onto the site, and by the microclimates of the site (discussed in the Natural Features section). The 2001 Management Plan reported that "most trees are less than 12 inches in diameter. It is estimated that there are approximately 45,000 or more trees in the Reserve, most of which are very young, small trees." This dense spacing and predominance of small trees continues today. In addition to the eucalyptus, other tree species located within the forest include Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus macrocarpa*), blackwood acacia (*Acacia*

[144] NPS 1996, 15; NPS 1999, 6.

[145] An 1896 newspaper article, written two years before Sutro's death and approximately 10 years after the first trees had been planted, stated that "extensive thinning has been done to benefit the trees" (Ryder 1896).

Fifteen years later, Emma Sutro Merritt, Sutro's daughter and the executrix of his estate, entered into a "contract with two private individuals [one of which was the Consolidated Eucalyptus Company] to thin out a portion of the forest according to property forestry methods and under the supervision of the Unites States forestry service." She was moved to defend these contracts because of the public impression that the entire forest was going to be logged. She explained: "The forest will be preserved and benefited by the work instead of being destroyed as stated" *San Francisco Chronicle* 25 March and 27 March 1909.)

In the early 1930s, a large logging operation within the forest employed 435 men (Brandi 2003, 40 and *San Francisco Chronicle* 15 October 1934). The extent of this logging operation over the entire south side of Mount Sutro is visible in a 1935 aerial photograph (Pacific Aerial Surveys 1935); See **Figure 14.** A WPA project sacked and warehoused the leftover wood from this logging operation to supply "indigent families with stove wood; as part of this project "certain areas previously logged" were cleaned and burned (Mooser 1938, 80 and 90).

The summit and the south face just below it were clear-cut around 1954 when the Nike site was built (Pacific Aerial Surveys 1955).

[146] Sixty acres "on the hill lying between the Affiliated Colleges and the Almshouse, in what is known as Sutro's Woods" burned in October 1899 (*San Francisco Chronicle* 1899), and Craig Dawson, in an email to Judy deReus (UCSF Campus Planning) noted that additional references to fires were found in newspaper articles in 1917, 1918, 1929, 1930, 1939, 1942, and 1948 (Dawson 2009). In fact, this fear of fires was one of the main reasons that Sutro's heirs limited public access to the forest (French 1906).

*melanoxylon*), coast redwood (*Sequoia sempervirens*), plum (*Prunus domestica*), cherry (*Prunus* spp.), and Bailey's acacia (*Acacia baileyana*).[147]

The forest understory is composed mainly of Himalayan blackberry, California blackberry (*Rubus ursinus*), elderberry (*Sambucus spp.*), French broom, snowberry (*Symphoriocarpus albus*), holly (*Ilex spp.*), myoporum (*Myoporum lactum*), toyon (*Heteromeles arbutifolia*), cotoneaster (*Cotoneaster lacteus*), Victorian box (*Pittosporum undulatum*), and currant (*Ribus spp.*). The most common groundcovers include English ivy (*Hedera helix*), poison oak (*Toxicodendron diversilobum*), fern (*Polystichum* spp.), and vetch (*Vicia* spp.). In all, 93 species of plants have been identified on Mount Sutro, with herbaceous perennials that grow low to the ground accounting for the majority of this diversity. The 2001 Management Plan described the understory as being dominated by the "rampant growth" of ivy, blackberry, other invasive exotic species, and the same conditions continue to exist today. Ivy grows up tree trunks and in locations along with the blackberry totally covers the ground plane.[148]

There are four areas that contain concentrations of native species. These include (1) an area with a coastal terrace community encircling the area north, east, and west of the Chancellor's residence, (2) a second coastal terrace community at the north edge of the summit clearing, (3) a native plant community consisting of several species of ferns located in the northwest portion of the Reserve on a north-facing embankment along lower Medical Center Way, and (4) small populations of California sagebrush and coyote bush at the summit clearing. Additionally, poison oak, sword fern, and elderberry occur throughout the site.[149]

The summit contains a native plant demonstration area planted in 2003 and funded by a $100,000 grant from the Rotary Club of San Francisco.

There are ornamental plants in the City-owned strip of land next to Crestmont Drive and some of these have spread into the adjacent western edge of the Reserve. A similar situation exists along the eastern edge of the Reserve where it abuts the residences along Edgewood Avenue.

The Aldea housing complex includes some individual specimens of mature eucalyptus and coastal redwoods as well as other exotic and native plant materials that have been planted as part of the ornamental landscape around this complex. The land around these buildings has been excluded from the legal boundary of the Reserve.

The 12-acre portion of the City-owned Interior Greenbelt that is adjacent to the east side of the Reserve has a eucalyptus forest that is basically indistinguishable from the Reserve since it, too, was part of the original Sutro

[147] EDAW 2110, 20-21.
[148] EDAW 2001, 20.
[149] HortScience et. al. 1999, IV-3; EDAW 2001, 20.

Forest planting and has experienced similar regeneration conditions. The 2001 Management Plan noted that the density of the trees in this area is generally higher than in the Reserve.[150]

There is separate stand of trees located south of Clarendon Avenue surrounding the base of Sutro Tower which is included within the City-owned Interior Greenbelt. The construction of Clarendon Avenue in the 1930s divided the forest into these separate areas.[151] This portion of the Interior Greenbelt south of Clarendon Avenue was not visited as part of the preparation of this Cultural Landscape Evaluation Report, but the trees on this property also have their origins in the original Sutro Forest planting.[152]

Until the mid-1950s, the forest on both sides of Clarendon Avenue remained largely intact. In the mid-1950s, the Midtown Terrace neighborhood altered the topography and resulted in the removal of the forest in the area south of Clarendon Avenue. The Forest Knolls development, started in the late 1950s, resulted in the removal of the portion of the forest in the area located between present-day Christopher and Crestmont drives and Laguna Honda and the north side of Clarendon Avenue. Earlier in the century, the construction of residential neighborhoods, such as Forest Hills, St. Francis Wood, and Sherwood Forest, had destroyed the southern portion of the Sutro Forest. Today the only large stands of trees remaining from the Sutro Forest are located at Mount Davidson and Mount Sutro. The trees at Mount Davidson are owned by the city and are managed by the San Francisco Recreation and Park Department. The trees at Mount Sutro include those within the University-owned Reserve and those on the adjacent, 12-acre, City-owned Interior Greenbelt parcel. **Figures 14-19** show aerial images of the Mount Sutro forest area between 1935 and 1987. **Figures 18-19** provide a comparison of the extent of the loss of the forest between 1946 and 1987.

## H. Small-Scale Features

Small-scale features in a cultural landscape may be functional, decorative, or both. Examples include site furnishings, fences, culverts, and monuments or memorials. They may be movable, used seasonally, or permanently installed. They may be designed or built for a specific site, standardized and available through a catalog, or created as vernacular pieces associated with a particular region, cultural group, or functional use.[153]

[150] EDAW 2001, 27.
[151] The portion of the Interior Greenbelt on the Sutro Tower hill was inherited by Sutro's son Edgar. Edgar's son Adolph Gilbert Sutro built the La Avanzada villa there in the early 1930s. He sold the house and surrounding land for $125,000 to the American Broadcasting Company in 1948 for use as their new television station transmitter site. The house was razed and the Sutro Tower was constructed in 1971-72 (July 2011).
[152] The management of the City-owned Interior Greenbelt is described in the *Significant Natural Resources Management Plan, Final Draft* (San Francisco: San Francisco Recreation and Park Department, 2006).
[153] NPS 1996, 16; NPS 1999, 6.

Small-scale features in the Reserve are generally associated with the present-day recreational or University-related uses. There are a few isolated remnants of past uses, possibly associated with the Nike site and with the original trails laid out by Sutro.

Examples of small-scale features that are associated with the present-day recreational use of the Reserve include trail markers, drainage culverts along the trails, and a storage area for trail maintenance materials (located at the intersection of the Nike Road and the road to the water tanks just south of the summit).

Examples of small-scale features related to UCSF include signs (i.e., the "San Francisco Rotary Meadow" sign at the summit, traffic signs, and directional signs), light fixtures, bollards and a chain across the entrance to the Nike Road, guardrails along Medical Center Way, and construction debris from the original Affiliated Colleges buildings located along the road to the water tanks just south of the summit.

Examples of small-scale features that may be associated with the Nike site include the remnant of a chain link fence just north of the East Ridge Trail and a guard rail along Nike Road.

There are about a half-dozen low, stone drywalls that act as retaining walls to support the outer edges of the Historic Trail where it passes through rock outcrops (i.e., where it would have been difficult to cut the grade and fill with soil). Similar examples of this type of edging or retaining wall have been found along the Fairy Gates Trail by the Sutro Stewards during their trail restoration efforts. Craig Dawson, Executive Director of the group, notes that this same type of drywall was found on another trail remnant in the Inner Greenbelt area. These walls are likely associated with the original construction of the trails by Adolph Sutro. Dawson notes that these walls reflect a common construction method of the period. Similarly constructed drystone retaining walls were used to support the edges of parcels on the west side of Stanyan Street, along the original east boundary of the Sutro Forest; this steeply sloped area was subdivided into level lots for residential construction in the mid-1880s.[154]

## I. Archaeological Features

The sites of prehistoric or historic activities or occupation may be marked by foundations, ruins, changes in vegetation, and surface remains or may be underground. These archaeological features provide valuable information about earlier uses, spatial organization, and features that are no longer intact or no longer evident on the ground's surface.[155]

[154] Dawson 2011.
[155] NPS, *National Register Bulletin 30* (1989), 6.

No archaeological resources have been recorded within the Reserve.[156] However two sites within the Reserve are unofficially associated with Ishi, the name given to the lone survivor of the northern California tribe of Yahi Indians, who lived and worked at the Anthropology Museum on the UCSF Parnassus Heights campus between 1911 and 1916. One site is the large rock outcropping which creates an overhang located southeast of the Chancellor's residence. The second is a deep cave with multiple chambers that is located northwest of the Chancellor's residence.[157]

[156] Much 2008, 1.
[157] EDAW 2001, V-2.

# VII. EVALUATION

## A. Summary of Significance and Period of Significance

Based on the analysis presented in this report, the Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 2 (Person) for its association with Adolph Sutro and his development of the Sutro Forest. The period of this significance extends from 1886 when Sutro first began to plant the Sutro Forest until his death in 1898. Beginning in 1886, Sutro conceived of and planted an expansive forest across the 1,200-acre tract of land that he purchased in San Francisco's Outside Lands in 1880; this planting included the Mount Sutro area. As part of his development of the cultural landscape Sutro appears to have constructed a trail system throughout the Mount Sutro area. Sutro's vision for the Mount Sutro area was conceived within late nineteenth-century naturalistic landscape design ideals and used this era's large-scale afforestation practices which viewed planting trees as a way to address concerns over a diminishing resource and as a way to improve the land. Other extant examples of late-nineteenth century, large-scale afforestation efforts in San Francisco include the Presidio Forest, trees at Stern Grove and Pine Lake Park, and plantings within Golden Gate Park.

Additionally, since the late nineteenth century, San Franciscans have identified Mount Sutro not only as a geographical feature but as a specific place—a wooded retreat within the city that affords them a naturalistic landscape experience and opportunities for recreation. The Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 1 (Events) for its association with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for the city. The period of this significance extends from 1886 when Sutro first began to plant the forest to the present.

## B. Boundary

The evaluation in this Cultural Landscape Evaluation Report includes the 61-acre Reserve, the major portion of the Mount Sutro Cultural Landscape.

However, the Mount Sutro Cultural Landscape consists of the 61-acre Reserve that is owned and managed by UCSF and a 12-acre portion of the City-owned Interior Greenbelt that extends from the east side of the Reserve to Stanyan Street. The Interior Greenbelt portion of the Mount Sutro Cultural Landscape has a eucalyptus forest, topography, and land use that are basically indistinguishable from those within the Reserve. There is no obvious or visual boundary distinction between these two areas. The forests on both properties (the Reserve and this portion of the Interior Greenbelt) were part of the original Sutro Forest planting and are associated with the significance of the Mount Sutro Cultural Landscape under California Register Criteria 1 and 2, as described in this report. However, the Interior Greenbelt is owned by the City and County of San Francisco and is managed by the San Francisco Recreation and Park Department.

Documentation of the existing conditions and an evaluation of the integrity of the Interior Greenbelt were outside of the scope of this report, and no survey was conducted of the Interior Greenbelt as part of this Cultural Landscape Evaluation Report.

A portion of the Interior Greenbelt extends south of Clarendon Avenue and surrounds Sutro Tower. The trees on this portion of the Interior Greenbelt also have their origins in the original Sutro Forest planting, but due to its location south of Clarendon Avenue, this area is no longer experienced as part of the Mount Sutro Cultural Landscape. The construction of Clarendon Avenue in the early 1930s severed the connection between the portions of the forest north and south of the street. Subsequent development (the addition of the Midtown Terrace housing development and the construction of Sutro Tower, the Summit Reservoir, and the Sutro Reservoir) further eroded the forested area south of the street and altered the landscape so that only a narrow strip of trees along the south side of Clarendon Avenue and the wooded area on the hillside around the Sutro Tower remain.

## C. Character-Defining Features

There are three categories of character-defining features within the Reserve, the major portion of the Mount Sutro Cultural Landscape, that convey its historical significance in association with Adolph Sutro and his development of the Sutro Forest between 1886 and his death in 1898 (under Criterion 2 [Persons]) and with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area for the city (under Criterion 1 [Events]). These categories of character-defining features include the forest (vegetation features), the trails (circulation features), and the topographic characteristics of the site (natural features).

The character-defining features related to the forest include the presence of a forest that covers the overwhelming majority of the land area within the Reserve and whose dominant species is eucalyptus.

The character-defining features related to the trails include the presence of the Historic and Fairy Gates trails as part of a consciously laid out trail system and the presence of informal or social trails which have developed over time related to land use activities and to provide connections into Mount Sutro from the surrounding neighborhoods.

The character-defining features related to the topographic character include the continued presence of the natural topographic characteristics of the site including the steep terrain, rock outcrops, Stanyan Canyon, and the summit.

More details on these character-defining features are found in the Vegetation Features, Circulation Features, and Natural Features subsections of the "Description and Analysis of Existing Conditions" section of this report.

## D. Integrity

Integrity is the ability of a property to convey its significance. The evaluation of integrity is grounded in an understanding of a property's physical features and how they relate to its significance. Integrity is composed of seven components or aspects—location, design, materials, workmanship, setting, feeling, and association.[158]

### *Summary of Integrity*

Although there have been a series of alterations to the forest stand throughout the years, today the most noticeable changes to the portion of the Mount Sutro Cultural Landscape located within the Reserve are the division of the landscape by the Medical Center Way and Johnstone Drive alignment and changes on the south slope due to the addition of the UCSF Aldea housing complex (which resulted in changes to the topography, the clear-cutting of trees, and the addition of roads and buildings). The construction of these and other University-related features have lessened the integrity of design, materials, and workmanship. Forest Knolls, located immediately adjacent to the west and south slopes of the Reserve, and the urban development south of Clarendon Avenue have removed trees from a portion of the area that was historically associated with the Mount Sutro forest. However, the Mount Sutro Cultural Landscape and the Reserve as a part of the Mount Sutro Cultural Landscape[159] continue to exhibit all seven aspects of integrity as explained in the more detailed discussion presented below.

### *Location*

Location is the place where the historic property was constructed or the place where the historic event occurred. Often the relationship between the property and its location is important in understanding why the property was created or why something happened.[160]

The location of the Mount Sutro Cultural Landscape—both its topographic prominence and its geographical location in the center of San Francisco—is a key component of its identity as a place. From this perspective, the location of Mount Sutro is unchanged and the Reserve retains its integrity of location as a part of the Mount Sutro Cultural Landscape.

### *Design*

Design includes such elements as organization of space, proportion, scale, technology, ornamentation, and materials. A property's design reflects historic functions and technologies as well as aesthetics. In a historic vernacular

[158] NPS, *National Register Bulletin 15: How to Apply the National Register Criteria* (2002), 44.
[159] The extant Mount Sutro Cultural Landscape consists of the 61-acre Reserve and the 12-acre portion of the City-Owned Interior Greenbelt that is located between the Reserve and Stanyan Street.
[160] NPS 2002, 44.

landscape, the evaluation of integrity is closely tied to land use and how the form, plan, and spatial organization of a property result from conscious and unconscious decisions over time about where areas of land use, roadways, buildings and structures, and vegetation are located in relationship to natural features and to each other.[161] In a landscape like Mount Sutro, its design is a composition of both natural and cultural elements.

There are four general types of cultural landscapes: historic sites, historic designed landscapes, historic vernacular landscapes, and ethnographic landscapes.[162] These types are not mutually exclusive and the present-day Mount Sutro Cultural Landscape has characteristics of both a historic designed landscape and a vernacular one. A historic designed landscape is one that was consciously designed or laid out by a landscape architect, master gardener, architect, engineer, or horticulturist according to design principles. The landscape may be associated with a significant person, trend, or event in landscape architecture or may illustrate an important development in the theory and practice of landscape architecture. Aesthetic values tend to play a significant role in designed landscapes. A historic vernacular landscape has evolved through use by the people whose activities or occupancy shaped it, and as a result function plays a significant role in vernacular landscapes.[163]

As noted in the "History" and "Description and Analysis" sections in this report, the Mount Sutro Cultural Landscape has its genesis in the conscious intent of Adolph Sutro to plant a large-scale forest throughout his 1,200-acre Rancho San Miguel. However, unlike Golden Gate Park and the Presidio Forest—two designed landscapes founded on the establishment of a large-scale forest during the same period—there does not appear to be a written or graphic plan for the Sutro Forest or for Mount Sutro as a specific location within the forest. Archival records show the existence of the infrastructure to carry out this grand plan (i.e., Sutro's wealth, the establishment of a nursery to provide trees, expenditures on trees and labor to plant the trees, etc.). However, no definitive written or graphic account of Sutro's ultimate plan or of his intensions for the new landscape he created is known to exist.

For the first 12 years of its existence, the development of the Sutro Forest (and Mount Sutro as a specific area within the larger forest) was directed by Sutro. However, whatever grand plan or intent Sutro envisioned for the Sutro Forest, in general, and for Mount Sutro, in particular, died with him. After his death in 1898, the 20-year battle within his family over the control of his estate, combined with the lack of funds to properly maintain his properties, limited Emma Sutro Merritt's (his daughter and the executrix of his estate) ability to maintain her father's vision for the Sutro Forest (as she understood it) to only the most basic of actions (i.e., protecting it from fire), and the Mount Sutro Cultural Landscape, as a part of this larger Sutro Forest, began to evolve more organically than had been the case

[161] NPS 2002, 44; NPS 1999, 22.
[162] NPS 1996, 4.
[163] Ibid., 5.

during Sutro's lifetime. After his death, the varied activities that occurred at Mount Sutro became the prime factors in shaping this cultural landscape, and it now exhibits the characteristics of a vernacular landscape. Generally there was always an acknowledgement that the forest originated with Sutro, but Mount Sutro has generally been perceived and treated as a "natural area" and not as a designed landscape. The cultural landscape's evolution was a byproduct of the regeneration of the forest and of activities that occurred within its boundaries. The site's natural topography, Sutro's initial planting of the predominantly eucalyptus forest, and his construction of a trail system established the foundation of this landscape. Subsequent activities and land uses—logging, fires, the Nike missile program, the development of land along the west and south sides for residential development, UCSF development, the ongoing use by the public for recreation, the general lack of planning for the maintenance of the forest in the past, and social trails development have all contributed to its current vernacular character.

Mount Sutro's historic designed landscape characteristics reflect its association with the late-nineteenth century forest planted by Adolph Sutro. The Mount Sutro portion of the Sutro Forest represents a small portion of the once expansive Sutro Forest that originally extended from Mount Sutro south to the vicinity of Ocean Avenue within the 1,200-acre tract of land that Sutro purchased in 1880 and that covered the land of the present-day Forest Knolls, Midtown Terrace, Forest Hill, St. Francis Wood, Sherwood Forest, Monterey Heights, Westwood Highlands, Westwood Park, Balboa Terrace, and Mount Davison Manor developments. The Mount Sutro portion of the forest extends into the adjacent 12-acre Interior Greenbelt parcel which is owned by the City and County of San Francisco and managed by the San Francisco Recreation and Park Department; this area is outside the scope of this report but would be considered part of the Mount Sutro Cultural Landscape. The loss of the overwhelming majority of the Sutro Forest has resulted in the loss of the integrity of design for the Sutro Forest (of which Mount Sutro is a part) in relationship to a historic design associated with Adolph Sutro. The integrity of design for the Mount Sutro Cultural Landscape area as a component of the Sutro Forest also has been impacted by the changes to the forest character as described below under the integrity of "Materials and Workmanship."

However, Mount Sutro's vernacular landscape character (or design) has evolved because of an overlay of activities and influences—the original development of the site by Adolph Sutro (planting the forest and laying out trails), the landscape's evolution into a naturalistic landscape within San Francisco's urban environment, and the landscape's informal use for recreation. The presence of a forest that is predominantly eucalyptus (its primary vegetation feature), the presence of a consciously laid out trail system (its primary circulation feature), the presence of informal or social trails which have developed over time related to land use activities and to provide connections into Mount Sutro from the surrounding neighborhoods, and the natural topographic characteristics of the site are features that have been consistently associated with its vernacular landscape

character (or design) since the late 1880s. All of these vernacular landscape characteristics remain today.

In summary, the integrity of design for the portion of the Mount Sutro Cultural Landscape located within the Reserve remains in relationship to its vernacular landscape character.

### *Materials and Workmanship*

National Register Bulletin 15 explains that materials are the physical elements that were combined during a particular period of time and in a particular pattern or configuration to form a historic property. The choice and combination of materials reveal the preferences of those who created the property and indicate the availability of particular types of materials and technologies.[164] Workmanship is strongly linked to materials and provides evidence of the technology or aesthetic principles of a historic period, and reveals individual, local, regional, or national applications of both technological practices and aesthetic principles.[165]

For the Mount Sutro Cultural Landscape, the key materials and associated workmanship are those associated with its character-defining features—the forest, the trail system, natural topographic characteristics, and recreational land use.

Materials and workmanship for the forest are reflected in the species, composition, and location and arrangement of the trees. The forest looks markedly different now than it did during Sutro's lifetime. The materials and workmanship for the portion of the Sutro Forest located within the Reserve has been altered by the regeneration process of the original stand of trees that has occurred over the past 120 years as impacted by logging and fires, by the past maintenance practices such as logging that has resulted in stump sprouting, by the spread of exotic species onto the site, by the microclimates of the site, and by the current dense spacing and predominance of small trees. However, with the exception of the summit, the Reserve continues to be covered by a dense stand of trees that is dominated (82 percent) by blue gum eucalyptus (*Eucalyptus globulus*). The presence of the forest and the predominance of the eucalyptus reflect the forest's origins from the trees planted by Adolph Sutro in the late 1880s and 1890s as part of the Sutro Forest.

Materials and workmanship for the designed trails (the Historic and Fairy Gates trails) are reflected in the grading and drystone retaining walls that modify the natural topography to create narrow level beds for the dirt-paved paths. Although these trails have been rehabilitated and in some places reconstructed by the recent efforts by the Sutro Stewards, the evidence of the historic use of materials and workmanship remains intact. To the extent possible given the addition of Medical Center Way, the Sutro Stewards followed the original alignment for the

[164] NPS 2002, 45.
[165] Ibid.

repairs and rebuilt the drystone walls using the original types of materials and construction techniques.

The materials and workmanship of the natural topographic characteristics of the Mount Sutro Cultural Landscape include the steep grades and rock outcroppings—both of which remain.

In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of materials and workmanship.

### *Setting*

Setting is the physical environment of a historic property and refers to the character of the place or location in which the property played its historical role. Setting involves how, not just where, the property is situated and its relationship to surrounding features and open space. Guidance in National Register Bulletin 15 directs that setting should be examined both within the exact boundaries of the property and between the property and its surroundings.[166]

During Adolph Sutro's lifetime, the setting within the Mount Sutro Cultural Landscape was that of a large, contiguous forest that was a part of the much larger Sutro Forest. During the first half of the twentieth century the total area of the Sutro Forest was dramatically reduced due to the city's development within its boundaries. However, the internal setting of the portion of the Mount Sutro Cultural Landscape located within the 61-acre Reserve continues to be dominated by a contiguous forest. The intrusions of the UCSF development within the Reserve (i.e., the Aldea housing complex, the Woods and Surge buildings and their respective parking lots, roads, etc.) has lessened the integrity of setting in the immediately adjacent areas, but outside of the direct sightlines of the UCSF features, the integrity of the setting remains.

Mount Sutro Cultural Landscape's setting in relationship to its surroundings—to the San Francisco landscape—is based on the contrast between the two. Initially, this contrast was between the dense, green expanse of forest that covered the peak, and the sparsely developed city landscape to the north, east, and west (the Sutro Forest originally extended to the south). Today, this contrast in setting is even more pronounced, and the dense urban development that surrounds it has resulted in a visual boundary that defines the area that is recognized by the public to be "Mount Sutro" (and that includes the portion of the City-owned Interior Greenbelt to the east).

In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of setting.

[166] NPS 2002, 45.

### *Feeling*

Feeling is a property's expression of the aesthetic or historic sense of a particular period of time.[167]

The feelings associated with the Mount Sutro Cultural Landscape include those generally associated with its forested areas, many of which are evoked by the senses: the colors of tree canopies within the mostly monocultural stands, the lower light levels within the forest due to the canopies of the trees, the smells associated with the eucalyptus trees and forest litter, the sounds of wildlife that live within the forest, the feelings of shelter or protection from the elements, the feeling of solitude, etc. Today, Mount Sutro continues to exhibit this integrity of feeling, and as was the case with the integrity of setting, the feelings associated with the Mount Sutro Cultural Landscape are intensified by the contrast to the feelings associated with San Francisco's highly urbanized environment that surrounds it.

In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of feeling.

### *Association*

Association is the direct link between an important historic event or person and a historic property.[168]

Association includes the events and historic contexts that helped to shape the development of the Mount Sutro Cultural Landscape during its period of significance (1886-1898 for its association with Adolph Sutro [under Criterion 2] and 1886-present for its association with recreational development within naturalistic landscapes in San Francisco [under Criterion 1]). While Mount Sutro developed as the result of a number of historical events or within a number of historic contexts, its key associations are with Adolph Sutro and his development of the Sutro Forest and with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area for the city. These two key associations remain as evidenced by the name "Mount Sutro" and its largely synonymous identification with the Sutro Forest, by the designation of the area as the "Mount Sutro Open Space Reserve" by the University of California Regents, and by the continuing use of the landscape as a recreational retreat from the urban city environment.

In summary, the portion of the Mount Sutro Cultural Landscape located within the Reserve retains its integrity of association.

[167] Ibid.
[168] Ibid.

## E. Summary of the Evaluation

The Reserve is a historical resource for the purposes of CEQA based on its eligibility for inclusion on the California Register of Historical Resources.

The evaluation in this Cultural Landscape Evaluation Report includes the 61-acre Reserve. The extant Mount Sutro Cultural Landscape consists of the 61-acre Reserve that is owned and managed by UCSF and the 12-acre portion of the Interior Greenbelt that is adjacent to the east side of the Reserve. The Interior Greenbelt is owned the City and County of San Francisco and is managed by the San Francisco Recreation and Park Department. Although there is a legal boundary between these two areas, there is no visible boundary, and the cultural landscape within the two is basically indistinguishable. Both the Reserve and this portion of the Interior Greenbelt were part of the original Sutro Forest planting. Historical accounts describe Stanyan Street as the eastern edge of the Sutro Forest, and the designed trail system around Mount Sutro appears to have extended through the Interior Greenbelt area down to Stanyan Street. No intensive survey was conducted within the Interior Greenbelt as part of this Cultural Landscape Evaluation Report, and an evaluation to document its existing conditions and its integrity as part of the extant Mount Sutro Cultural Landscape was outside of the scope of this report.

The Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 2 (Person) for its association with Adolph Sutro and his development of the Sutro Forest; the period of this significance extends from 1886 when Sutro first began to plant the Sutro Forest to his death in 1898. Additionally, the Reserve appears to be significant as part of the Mount Sutro Cultural Landscape under California Register Criterion 1 (Events) for its association with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for the city; the period of this significance extends from 1886 when Sutro first began to plant the forest to the present.

The Reserve maintains its integrity related to these two areas of significance.

The character-defining features that convey its historical significance include (1) the presence of a forest that covers the overwhelming majority of the land area and whose dominant species is eucalyptus, (2) the presence of the Historic and Fairy Gates trails as part of a consciously laid out trail system and the presence of informal or social trails which have developed over time related to land use activities and to provide connections into Mount Sutro from the surrounding neighborhoods, and (3) the natural topographic characteristics of the site including the steep terrain, the rock outcrops, Stanyan Canyon, and the summit.

# VIII. IMPACTS ANALYSIS

The following evaluation of the impacts to the Reserve as a historical resource is based on the description of the proposed activities provided by UCSF Campus Planning in December 2012.[169]

## A. Proposed Project

### *Overview*

The proposed project would involve implementation of a number of management activities, including thinning of the forest, native plant restoration and enhancement, and conversion planting (removal of non-native trees and plants and conversion to native species). Vegetation management actions are proposed to occur throughout the Reserve over many years and would be phased beginning with four demonstration projects that were crafted with the interested public in the community process described below. The first three demonstration projects are planned for implementation following the completion of environmental review and project approval. The fourth demonstration project would be implemented approximately one year after the first three demonstration projects. Also, a "Hands-Off" management area in which no vegetation management would be undertaken for the one-year duration of the demonstration project timeframe is proposed as requested by some community members. The demonstration projects would include a range of potential management actions that could be implemented later throughout the entire Reserve. Such actions would be first implemented in these four small areas to "demonstrate" to the public the range of potential results. Public feedback would then inform the University's choices in the management activities to be applied to the remainder of the Reserve over time. The management actions identified for the demonstration areas are proposed to be applied ultimately beyond the demonstration areas to the remainder of the Reserve, as appropriate, subject to further refinement by UCSF in consultation with the interested public. See **Figure 51** for the location of the demonstration areas. Trail system improvements, including new trails and switchbacks, are also being proposed. The creation of these new trails would require minimal vegetation removal, minor amounts of grading, and the addition of new trail markers. See **Figure 52** for the location of the proposed trail system improvements.

Several principles would govern the implementation of management activities, including:

- Adaptive Management: UCSF is committed to the principle of adaptive management as defined in the 2001 Management Plan, allowing for public input and opinion and adjustment of

[169] Diane Wong (Senior Planner/Environmental Coordinator, UCSF Campus Planning), Email to Denise Bradley, 11 December 2012.

management activities before application to other areas of the Reserve.

- Limited Use of Herbicides: Where herbicide use is indicated, targeted spot-application methods would be employed on tree stumps, vine, blackberry and broom stems, and on poison oak adjacent to trails.

- Tree Spacing: Where tree removal is indicated, the priority for removal is dead, dying, unhealthy, and hazardous trees. Where trees must be removed to achieve desired spacing, the next priority would be removal of trees smaller than 12 inches in diameter, followed by removal of trees larger than 12 inches in diameter.

The management activities related to the Demonstration Projects, Continued Implementation, Trails, and Ongoing Maintenance are described below.

***Demonstration Areas***

Demonstration Project 1: South Ridge Area (3 acres)

A summary of the activities proposed for Demonstration Project 1 includes the following:

Trees

- Removal of all vines on tree trunks up to about 10 feet in height.

- Prune branches as needed to remove fire ladders and hazards.

- Removal of dead and unhealthy trees.

- Tree thinning of remaining trees to average spacing of about 30 feet between trunks.

- Tree stump treatment: 1 acre – rely on hand maintenance; 1 acre – cover with tarps; 1 acre – apply herbicides.

- Sprout control: cut mechanically or use goat grazing 1-2 times per year for 3-5 years in 1 acre where stumps are not tarped or treated with herbicide.

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak); islands of brush will be maintained for wildlife.

- Spot-treat cut tree vines, blackberry stems and poison oak adjacent to trails with herbicide in 1 acre.

- Mow, use goat grazing and/or use herbicides consistent with city standards, annually or every other year for 5 years, depending on rate of re-growth.

Refer to **Figure 51** for the location of Demonstration Project 1.

Demonstration Project 2: Edgewood Avenue Area (2 acres)

A summary of the activities proposed for Demonstration Project 2 includes the following:

Trees

- Removal of all vines on tree trunks up to about 10 feet in height.
- Prune branches as needed to remove fire ladders and hazards.
- Removal of dead and unhealthy trees.
- Tree thinning minimal, mostly acacias. Of those areas to be thinned, remaining trees to average spacing of about 30 feet between trunks, close to the spacing that currently exists in most of this area.
- Tree stump treatment: cover with tarps.
- Sprout control: maintain tarps until stumps are dead.

Understory

- Initially, mow up to 90-100% (excluding native plants).
- Mow and/or use goat grazing annually or every other year for 5 years, depending on rate of regrowth.

Refer to **Figure 51** for the location of Demonstration Project 2.

Demonstration Project 3: North Side of Summit (less than 0.5 acre)

A summary of the activities proposed for Demonstration Project 3 includes the following:

Trees

- Remove trees minimally, only as needed to prevent shading of existing Nootka reed grass area.
- Remove trees minimally, only as needed to maintain a clear view corridor to the northeast.
- Tree stump treatment: cover with tarps.

- Sprout control: maintain tarps until stumps are dead.

Understory

- Hand-remove non-native plants from grass area.

Refer to **Figure 51** for the location of Demonstration Project 3.

Demonstration Project 4: East Bowl Corridor (2 acres)

A summary of the activities proposed for Demonstration Project 4 includes the following:

Trees

- Removal of all vines on tree trunks up to about 10 feet in height.
- Prune branches as needed to remove fire ladders and hazards.
- Removal of dead and unhealthy trees.
- Tree thinning of remaining trees to average spacing of about 60 feet between trunks.
- Tree stump treatment and sprout control would depend on outcome of Demonstration Project 1, but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used.
- Planting of native shrubs and trees (1 acre irrigated, 1 acre non-irrigated).

Understory

- Initially, mow up to 90-100% (excluding native plants; including poison oak along trails); large areas of underbrush are expected to be maintained in this demonstration area.
- Re-growth control depends on outcome of Demonstration Project 1 but for purposes of this analysis, it is assumed that herbicides, perceived by some community members as being the most impactful, would be used (herbicides would not be used if it can be demonstrated in Demonstration Project 1 that undesirable understory plants can be controlled at a reasonable cost without herbicides).

Refer to **Figure 51** for the location of Demonstration Project 4.

"Hands-Off" Management Area: South Ridge Area (2 acres)

A summary of the activities proposed for the "Hands-Off" Management Area includes the following:

Trees

- No changes to existing trees, except that maintenance will be performed to remove and prune hazardous trees near homes and trails for the safety of residents and visitors and to keep trails clear (including trash pick-up).

Understory

- Understory would remain as is.
- Trails would be kept clear, including trash removal.

Refer to **Figure 51** for the location of the "Hands-Off" Management Area.

***Continued Implementation***

Following the completion and assessment of the Demonstration Projects: targeted management actions would potentially be applied to the remainder of the Reserve. A summary of the proposed activities includes the following:

Trees

- Removal of all vines on tree trunks up to about 10 feet in height
- Prune branches as needed to remove fire ladders and hazards
- Removal of dead and unhealthy trees
- Tree thinning of remaining trees to average spacing of about 30 feet between trunks, except in Demonstration Area #4, East Bowl Corridor, where average trunk spacing would be roughly 60 feet to accommodate plantings of redwood, willow, and bay trees and native forbs and shrubs.
- In some select areas along trails and at the summit, trees would be removed to create views.
- Steep slopes that are inaccessible by heavy equipment (about 15 acres) would not be thinned.
- The large scale thinning work would be phased – no more than a quarter of the Reserve would be thinned at any given time.
- Tree stump treatment and sprout control would depend on the outcome of the Demonstration Projects, and could include techniques such as covering with tarps, sprout cutting, or goat grazing. For purposes of a conservative EIR analysis, it is assumed, as a worst-case scenario, that herbicides will be used.
- Selective planting of native shrubs and trees.

Regarding the select planting of native shrubs and trees, the 2001 Management Plan discussed conversion planting locations on the summit, in the East Bowl Corridor (Demonstration Area #4), and in the South Ridge Area (including in Demonstration Area #1). As discussed, the summit has been planted with a native plant garden. Conversion planting in the East Bowl Corridor would be completed as part of Demonstration Project #4). The 2001 Management Plan identified for the South Ridge area the planting of Monterey cypress to create a windbreak ("Area J" in the 2001 Management Plan), and the planting of Oak Woodland ("Area K"). The Monterey cypress windbreak is no longer proposed. In the future, Oak Woodland may be planted in Area K, an area of roughly 1.5 acres, should funding become available.

Of the Reserve's 61 acres, conversion planting would occur in the East Bowl Corridor (about 2 acres) and potentially in Area "K" (about 1.5 acres). Accounting for the summit (about 1.5 acres), the remaining area predominantly containing eucalyptus would be about 56 acres. Thus, the overwhelming majority of the Reserve would remain a eucalyptus forest, although at a lesser density than exists today.

Understory

- Initially, mechanically remove (via mowing, cutting) up to about 90% of the non-native biomass, including poison oak along trails. Large areas of underbrush are expected to be maintained, and steeper slopes (>40 percent) may not be cut at all.

- Re-growth control may be conducted using various techniques including mowing, goat grazing, and/or herbicides, which would be applied annually or every other year for 5 years, depending on the rate of re-growth.

### *Trails*

Over the past several years, trails have been restored and enhanced to improve access throughout the Reserve for the enjoyment of visitors. For example, an historic trail that was only recently discovered was restored by the Mount Sutro Stewards. Three new trails are proposed as part of the project: (1) a trail on the north side of the Reserve connecting the Historic Trail to the campus, allowing for ease of access to/from the campus; (2) a trail connecting the South Ridge Trail to Christopher Drive, allowing for easier public access from the south side of the Reserve; and (3) an extension of this new trail to Clarendon Avenue and to trails to the Interior Greenbelt (on City-owned land) and southeast of the Reserve. The creation of these new trails will require minimal vegetation removal, minor amounts of grading and new trail markers.[170]

[170] Ibid., 8.

See **Figure 52** for the locations of existing trails within the Reserve and locations of the three proposed new trails.

### *Ongoing Maintenance*

UCSF, with the assistance of the UCSF Mount Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees, and restoring trails. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

### *Best Management Practices*

The following best management practices (BMPs) are incorporated into the proposed project:

1. Disturbance to existing grades and vegetation will be limited to the actual treatment or restoration areas and necessary access routes. Placement of all trails, staging areas and other facilities will avoid and limit disturbance to existing native plants to the maximum extent practicable, with the exception of poison oak. Where possible, existing ingress or egress points will be used and contours of the work area will be returned to pre-construction conditions.

2. Disturbed soils resulting from treatment activities will be stabilized prior to the rainy season by spreading woodchips or shreds or other mulch materials over the bare ground.

3. Straw wattles, silt fencing, straw bales, or similar sediment control measures will be installed on contours along the lower edge of the treatment areas to prevent excess sediment from entering the watershed, if deemed necessary.

4. To avoid attracting predators, food-related trash will be disposed in closed containers and regularly removed from the work areas.

5. All construction material, wastes, debris, sediments, rubbish, vegetation, trash, fencing, etc., will be removed from the site upon completion of treatments and transported to an authorized disposal area, as appropriate, and per all federal, State and local laws and regulation.

6. All construction-related holes will be covered to prevent entrapment of native amphibians, reptiles and small mammals.

## B. Analysis of the Potential for Impacts to the Reserve as a Historical Resource

Under CEQA, historical resources are considered part of the environment, and a project that may cause a substantial adverse effect on the significance of an

historical resource is a project that may have a significant effect on the environment.

Substantial adverse change in the significance of an historical resource means physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of an historical resource would be materially impaired. The significance of an historical resource is materially impaired when a project demolishes or materially alters in an adverse manner those physical characteristics of an historical resource that convey its historical significance and that justify its inclusion in, or eligibility for, inclusion in the California Register of Historical Resources.[171] The website of the Office of Historic Preservation explains that the "physical characteristics of an historical resource that convey its historical significance" are its character-defining features.[172]

The Reserve appears to be eligible for listing in the California Register of Historical Resources as the major portion of the Mount Sutro Cultural Landscape, as described in the "Evaluation" section of this report, and is therefore determined to be a historical resource for the purposes of CEQA.

Critical to the Reserve's eligibility for listing in the California Register are three categories of character-defining features associated with Mount Sutro's cultural landscape significance that convey its historical significance in association with Adolph Sutro and his development of the Sutro Forest between 1886 and his death in 1898 (Criterion 2 [Persons]) and with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for the city (Criterion 1 [Events]). These character-defining features include:

- A forest that covers the overwhelming majority of the land area and whose dominant species is eucalyptus.
- The presence of the Historic and Fairy Gates trails as part of a consciously laid out trail system and the presence of informal or social trails which have developed over time related to land use activities and to provide connections into the Mount Sutro Cultural Landscape from the surrounding neighborhoods.
- The natural topographic characteristics of the site including the steep terrain, rock outcrops, Stanyan Canyon, and the summit.

More details on these character-defining features are found in the Vegetation Features, Circulation Features, and Natural Features subsections of the "Description and Analysis of Existing Conditions" section of this report.

[171] State CEQA Guidelines Section 15064.5 (b)[1] and [2][A].
[172] Office of Historic Preservation website, "What is Substantial Adverse Change to a Historical Resource?"; http://ohp.parks.ca.gov/?page_id=21726.

The following analysis discusses the potential for the material impairment of these character-defining features as the result of the management activities related to the Demonstration Projects, Continued Implementation, Trails, and Ongoing Maintenance.

### *Four Demonstration Areas and the "Hands-off" Area*

The proposed Management Plan activities related to the four demonstration areas and the "Hands-off" area were reviewed for their potential to materially impair the character-defining features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the four demonstration areas and the "Hands-off" area activities would demolish or materially alter in an adverse manner the physical characteristics—the character defining features consisting of a forest whose predominant species is eucalyptus, the trail system and the natural topographic characteristics—of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources.

The evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the activities would be limited to the four demonstration areas; (2) the demonstration areas are located within different parts of the Reserve so that the activities would not be concentrated in any one zone or part of the Reserve; (3) the total area within the demonstration areas would affect only about 7.5 acres of the total 61 acres of land within the Reserve, (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape, and (5) the Reserve would continue to exhibit its seven components of integrity (location, design, materials, workmanship, setting, feeling, and association) as described the "Evaluation" section. In summary, the proposed activities related to the four demonstration areas and "Hands-off" management area would have a less-than-significant impact on the Reserve as a historical resource.

### *Continued Implementation*

After the completion and assessment of Demonstration Project 2: Edgewood Avenue Area, management actions in Demonstration Project 2 would be selected for application to the remainder of the Edgewood Avenue Area (shown on Figure 3-4 as area "I" and including lands west of area "I' to Medical Center Way), including the planting of native trees, shrubs and other plants as understory within the existing forest whose predominant species is eucalyptus.

In addition, after the completion and assessment of the Demonstration Project 1: South Ridge Area, management actions proposed in Demonstration Project 1 would be selected for application to other areas of the Reserve, excluding the other demonstration project areas, and the Rotary Meadow at the summit.

These management actions would include the planting of native species and enhancement of existing remnant native plant communities.

Of the Reserve's 61 acres, conversion planting would occur in the East Bowl Corridor (about 2 acres) and potentially in Area "K" (about 1.5 acres). Accounting for the loss of eucalyptus-forested area due to these proposed conversion plantings and the conversion of the summit (about 1.5 acres) that has already occurred, about 56 acres of forested area would remain where the predominant species is eucalyptus. Thus, the overwhelming majority of the Reserve would remain a eucalyptus forest, although at a lower density of trees per acre than exists today.

The activities related to the continued implementation of the proposed Management Plan were reviewed for their potential to materially impair the character-defining features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the full implementation of these activities (i.e., the implementation of the Demonstration Project 2 management actions throughout the Edgewood Area, the implementation of the Demonstration Project 1 management actions throughout other areas of the Reserve [excluding the other demonstration project areas and the Rotary Meadow at the summit], and the planting of native species and enhancement of existing remnant native plant communities) would demolish or materially alter in an adverse manner the physical characteristics—the character defining features consisting of a forest whose predominant species is eucalyptus, the trail system and the natural topographic characteristics—of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources.

This evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the proposed vegetation management actions described in Section 3.5.2.: Continued Implementation, (2) the best management practices described in Section 3.5.5: Best Management Practices, (3) 56 acres of forested area where the predominant species is eucalyptus would remain, (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape, and (5) the Reserve would continue to exhibit its seven components of integrity (location, design, materials, workmanship, setting, feeling, and association) in the "Evaluation" section. In summary, the proposed activities related to the continued implementation of the proposed Management Plan would have a less-than-significant impact on the Reserve as a historical resource.

### *Trail System Improvements*

The proposed Management Plan activities related to the trail system improvements, including the addition of three new trails and new switchbacks, were reviewed for their potential to materially impair the character-defining

features of the Reserve as part of the Mount Sutro Cultural Landscape. Based on this review, it does not appear that the trail system improvements would demolish or materially alter in an adverse manner the physical characteristics of the Reserve that convey its historical significance and that justify its eligibility for the California Register of Historical Resources—the character-defining features consisting of a forest whose predominant species is eucalyptus, the trail system, and the natural topographic characteristics.

The evaluation and conclusion was made based on the following key components of the proposed Management Plan: (1) the trail system improvements would result in minimal vegetation removal; (2) the grading proposed would be limited to minor alterations in the topography in the vicinity of the trail improvements; (3) the existing trails and the three new proposed trails would remain unpaved and (4) the character-defining features, listed above, would all remain and would continue to convey the significance of the Reserve as part of the Mount Sutro Cultural Landscape. In summary, the proposed activities related to the trail system improvements would have a less-than-significant impact on the Reserve as a historical resource.

### *Ongoing Maintenance*

UCSF, with the assistance of the Sutro Stewards, has maintained the Reserve by pruning trees and bushes, removing hazardous trees and restoring trails. The goals and general description for ongoing maintenance are consistent with the protection of the Reserve as a historical resource. Ongoing maintenance would continue as needed, and, as in the past, would be reviewed for compliance with CEQA.

## C. Cumulative Impacts Analysis

"Cumulative impacts" refer to two or more individual effects which, when combined, are considerable or which compound or increase other environmental impacts.

> (a) The individual effects may be changes resulting from a single project or a number of separate projects.
>
> (b) The cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time.[173]

The cumulative impact analysis encompasses the entire extant of the Mount Sutro Cultural Landscape including both the 61-acre Reserve and the 12-acre

[173] State CEQA Guidelines Section 15355 (a) and (b).

portion of the Interior Greenbelt east of the Reserve extending to Stanyan Street. The cumulative analysis considers whether the incremental contribution of the proposed project, in combination with other past, present and reasonably foreseeable projects, would have a cumulatively considerable impact to the Mount Sutro Cultural Landscape.

In addition to the proposed project, future cumulative projects that have the potential to affect the historical significance of the Mount Sutro Cultural Landscape include the City's management strategies for the Interior Greenbelt as defined in the *Significant Natural Resource Areas Management Plan* (SNRAMP).[174] The SNRAMP activities proposed in the Interior Greenbelt would focus on (1) improving public access on designated trails, (2) restoring the creek riparian corridor, (3) creating a more structurally diverse urban forest habitat for wildlife, and (4) creating increased and more sustainable populations of sensitive plant species. The SNRAMP stated that "[i]mplementation of the management recommendations at the Interior Greenbelt would not change significantly the overall look of the park."[175]

Specific vegetation management activities that would occur in the project vicinity under the SNRAMP would include managing herbaceous invasive plants such as Himalayan blackberry, Cape ivy, and Algerian ivy (Recommendation IG-1a), removing approximately 140 eucalyptus trees to enhance seasonal creek and sensitive species habitats (Recommendation IG-1b),[176] revegetation using native plants to maintain and enhance the existing scrub mosaic communities (Recommendation IG-1c), augmenting existing populations of sensitive plants (Recommendation IG-1d), and considering reintroduction of specific rare plant species (Recommendation IG-1e). Eucalyptus trees would be removed from 1.3 acres of the 12-acre area in the Interior Greenbelt parcel that adjoins the Reserve to the east. The SNRAMP stated that in the short term "the surrounding neighborhood and visitors may notice a decrease in tree density after thinning is complete, but the overall view will not be substantially altered."[177] In the long term "[t]hese areas will be converted to coastal scrub or creek riparian habitats. Once the vegetation is established, the area will appear forested and natural with no evidence of tree removal or disturbance."[178] Trees throughout the remaining 10.7 acres would be managed as an urban forest following general urban management practices to promote the health and diversity of the forest and wildlife habitat (as outlined in General Recommendations GR-15).[179]

[174] EIP Associates, Significant Natural Resource Areas Management Plan, Final Draft (San Francisco Recreation and Park Department, 2006).
[175] Ibid., page 6.23-3.
[176] Approximately 100 "small and medium-sized" eucalyptus trees would be removed from a one-acre area (designated as "MA-2a") along the eastern boundary of the 12-acre northern parcel near Stanyan Street as part of creek enhancement; the SNRA Management Plan estimated that this represented 28 percent of the trees in this one-acre area. Additionally, approximately 40 eucalyptus trees would be removed from a 0.3-acre area (designed as "MA-2c") in the western tip of this same parcel along its boundary with the Reserve (Recommendation IG-1b); the SNRA Management Plan estimated that this represented 45 percent of the trees in this 0.3-acre area (EIP Associates 2006, page 6.23-4 and Table F-1).
[177] Ibid., F-10.
[178] Ibid., F-11.
[179] Ibid., page 6.23-4 to 5, Figure 6.23-5, and Table F-1.

Under the SNRAMP, the City plans to develop a new trail linking existing secondary trails with trails on the Reserve (Recommendation IG-2a). Additionally the City would formalize existing social trails that would remain to minimize erosion and to protect creek habitat (Recommendation IG-2b). In June 2011, the City reopened the Lower Historic Trail. The eastern trailhead for this reconstructed trail is located on Stanyan Street at 17th Street and the western end connects to the Edgewood Trail just inside the Reserve.

The proposed project, in combination with the City's management strategies for the Interior Greenbelt as defined in the SNRAMP would not result in an alteration to the historic character of the Mount Sutro Cultural Landscape and would not result in a material impairment of its historical significance in association with Adolph Sutro and his development of the Sutro Forest (California Register Criterion 2 [Persons]) or with the history of San Francisco and the informal development of this naturalistic landscape as a recreational area and green space for San Francisco (California Register Criterion 1 [Events]).

The proposed project is intended to provide a benefit by maintaining, improving and restoring the Reserve and would not contribute to long-term, adverse cumulative impacts on the Reserve as a historical resource. No other UCSF or City projects are currently proposed in a sufficiently close proximity such that cumulative impacts related to historical resources would be anticipated. Therefore, the proposed project would not contribute to cumulative adverse impacts related to historic resources.

## IX. BIBLIOGRAPHY

A. L. Bancroft & Company
1873 *Bancroft's Official Guide Map of the City and County of San Francisco, Compiled from Official Maps in Surveyor's Office*. San Francisco: A. L. Bancroft & Company. David Rumsey (accessed 11 February 2011)

Baldwin, A. S.
1910 *Estate of Adolph Sutro [Album]*. San Francisco: n. p. Available in the San Francisco History Center, San Francisco Public Library.

Bancroft, A.L.
1873 Official Map of the City and County of San Francisco. San Francisco: A.L. Bancroft & Co. Available in the San Francisco History Center, San Francisco Public Library.

Beatty, Russell A.
2001 "The Planting of Golden Gate Park: A Metamorphosis in Sand" in *The Trees of Golden Gate Park and San Francisco*. Berkeley: Heyday Books/Clapperstick Institute.

Bradley, Denise
2005 *Identification of the Cultural Landscape Features at Lands End and Discussion of the Potential for Effects Related to Lands End Coastal Trail Project (GGNPC Project No. 3102-501-12), 12 December 2005.* Submitted to Golden Gate National Parks Conservancy.

2009 Historic Forest Character Study, Presidio of San Francisco, San Francisco, CA: Summary of Significance and Integrity and Analysis of Character-Defining Features. Prepared for The Presidio Trust, October 2009.

Bradley, Denise and Michael R. Corbett
1999 National Register of Historic Places Registration Form: Sutro Historic Landscape District, San Francisco, CA, Draft. Prepared for Golden Gate National Recreation Area, San Francisco, CA.

2004 Final Draft, Cultural Landscape Report with National Register and California Register Evaluation for the Stern Grove and Pine Lake Park Historic District, July 2004. Available as an appendix in the *Sigmund Stern Grove and Pine Lake Improvement Plan: 2003.0112E / San Francisco Planning Department* (San Francisco Planning Department 2005).

Brandi, Richard
2003 "Farms, Fire and Forest: Adolph Sutro and Development 'West of Twin Peaks,'" *The Argonaut*, Vol. 14, No. 1 (Summer 2003): 36-49.

2005 *Images of America: San Francisco's West Portal Neighborhoods.* San Francisco: Arcadia Publishing.

California Historical Society.
Various dates Sutro Papers.

California. Office of Historic Preservation
n.d. *Technical Assistance Series #6: California Register and National Register: A Comparison (for purposes of determining eligibility for the California Register)*, accessed 9 January 2013, http://ohp.parks.ca.gov/.

2001 *Technical Assistance Series #7: How to Nominate a Resource to the California Register of Historical Resources*, accessed 30 January 2011, http://ohp.parks.ca.gov/.

Carey & Co., Inc.
2003 *Draft Historic Evaluation Report, University of San Francisco Parnassus Heights Campus, San Francisco, California, September 2003*. Prepared for ESA Associates, San Francisco, California.

2010 *Draft UCSF Historic Resources Survey, San Francisco, California, 31 July 2010*. Prepared for the University of California, San Francisco.

Cohen, Katherine Powell
2008 *Images of America: San Francisco's Haight-Ashbury*. San Francisco: Arcadia Publishing.

[Chronicle Publishing Company]
1959 Hills of San Francisco. [San Francisco: Chronicle Pub. Co.]

Cram, George F.
[1901] *Map of the City of San Francisco*. Chicago: C. F. Cram. Available University California, Berkeley Earth Sciences Library Map Room.

Davidson, Russ
2003 "Adolph Sutro As Book Collector: A New Look." *California State Library Foundation Bulletin* No. 75 (Spring/Summer 2003): 2-27.

Dawson, Craig (Executive Director, Sutro Stewards)
2009 Email to Judy deReus, 30 July 2009. RE: FEMA—Fire History. Forward by Diane Wong, 3 December 2010.

2011 Emails to Denise Bradley discussing trails. 18 and 22 February.

deReus, Judy (Project Manager, UCSF Campus Planning)
2009 Letter to Paul Ransom (California Emergency Management Agency), 16 August 2009. RE: FEMA's request for clarifications for UCSF's Mount Sutro South Ridge (PDMC-PJ-09-CA-2007-010) and Edgewood Avenue (PDMC-PJ-09-CA-2009-001) Vegetation Management Projects.

EBMUD
2004 *Plants and Landscapes for Summer-Dry Climates of the San Francisco Bay Region*. Oakland, CA: EBMUD.

EDAW Inc.
2001 *Mount Sutro Open Space Reserve Management Plan, September 2001*. Prepared for the University of California, San Francisco.

EIP Associates
2006 *Significant Natural Areas Master Plan, February 2006, Final Draft.* Prepared for the San Francisco Recreation and Park Department. http://sf-recpark.org/index.aspx?page=628 (accessed 4 August 2011).

French, Harold.
1905 "A Mountain Wilderness in the City's Heart." *Overland Monthly*, Vol. 46 (July-December 1905: 136-139.

1906 "San Francisco Sierras: A Panorama Equalled in Variety by No Hill Crowned City in the World." *San Francisco Chronicle*, 16 December 1906: 5.

Fontes, Marsha
1991 "Stern Grove" in West Portal Monthly, December 1991, pp. 9-10. Copy available in vertical files at the San Francisco History Center. Cited in Denise Bradley and Michael Corbett, *Final Draft, Cultural Landscape Report* . . . (2004).

Gaar, Greg and Ryder W. Miller
2006 *Images of America: San Francisco A Natural History*. San Francisco: Arcadia Publishing.

Garibaldi, Rayna.
2007 *Images of America: San Francisco's Portola*. San Francisco: Arcadia Publishing.

Gilliam, Harold (text) and Michael Bry (photographs)
1967 *The Natural World of San Francisco*. Garden City, NY: Doubleday & Company, Inc.

Goddard, George H.

1868 *Birdseye View of San Francisco and Surrounding County*. San Francisco: Snow & May. http://www.davidrumsey.com (accessed 11 February 2011).

Google Earth.
1946, 1987, 1993, 2002, and 2011 Aerial photographs (assembled from various sources) that show the Mount Sutro area.

Greene, George M., [Jr.]
ca.1938 "Historical Events Pertaining to 'The Trocadero.'" Typewritten manuscript. Copy available from the California Historical Society. Cited in Denise Bradley and Michael Corbett, *Final Draft, Cultural Landscape Report* . . . (2004).

Groenendaal, Gayle M.
1983 "Part 1. History of Eucalypts in California: Eucalyptus Helped Solve a Timber Problem, 1853-1880," in *Proceedings of a Workshop on Eucalyptus in California, June 14-16, 1983, Sacramento, California, Pacific Southwest Forest and Range Experiment Station, General Technical Report PSW-69* (Standiford, Richard B. and F. Thomas Ledig, Technical Coordinators). Berkeley, CA: United States Department of Agriculture, Forest Service. Copy available at the Helen Crocker Russell Library of Horticulture, San Francisco Botanical Garden at Strybing Arboretum.

Hayes, Elinor
1969 "Sutro Tower to Replace Historic Mountain Villa." *Oakland Tribune*, 19 October.

Holmes, Eugenia Kellog
1895 *Adolph Sutro: A Brief Story of A Brilliant Life*. San Francisco: Press of San Francisco Photo-Engraving Co.

HortScience, Inc., Kelley and Associates Environmental Sciences, Royston, Hanamoto Alley & Abey, and Martin Whitcomb Landscape.
1999 *Mount Sutro Open Space Reserve Maintenance and Restoration Plan, UCSF Project No. M5351, July 1999*. Prepared for University of California San Francisco, Campus Planning Office.

Jones, William A.
1883 *Plan for the Cultivation of Trees Upon the Presidio Reservation. Prepared by Major W. A. Jones, Engineer Office, Headquarters Department of California, Presidio of San Francisco, 26 March 1883*.

1902 "Suggestions in the matter of parking the U.S. Military reservation of the Presidio of San Francisco" in Erwin N. Thompson, *Defender of the Gate: The Presidio of San Francisco, A History from 1846 to 1995* (Denver: National Park Service, Denver Service Center. July 1997).

July, David
2011 Mount Sutro: An Electronic Periodical. http://www.sutrotower.org/ (accessed 8 February 2011)

LaBounty, Woody.
2003 Ingleside/Lakeview. Western Neighborhoods Project's Website. http://www.outsidelands.org/ingleside-lakeview.php (accessed 10 February 2011)

Land and Community Associates in association with EDAW, Inc.
1993 *Sutro Historic District: Cultural Landscape Report.* San Francisco: National Park Service, Golden Gate National Recreation Area. Excerpted and edited in Denise Bradley and Michael Corbett, National Register of Historic Places Registration Form: Sutro Historic Landscape District, San Francisco, CA, Draft, 1999.

Lull, G. B., Assistant Forest Inspector, [U.S.] Forest Service
1906 *Report on a Preliminary Examination of the Military Reservations in and Around San Francisco Bay And Benicia Arsenal Reservation, June 1906*.

McClatchie, Alfred James
1902 *Eucalypts Cultivated in the United States, U.S. Department of Agriculture, Bureau of Forestry, Bulletin No. 35*. Washington: Government Printing Office. Available in the Helen Crocker Russell Library of Horticulture, San Francisco Botanical Garden at Strybing Arboretum.

McClintock, Elizabeth
2001 *The Trees of Golden Gate Park and San Francisco.* Berkeley, CA: Heyday Books/Clapperstick Institute.

McLaren, John
1908 *Gardening in California, Landscape and Flowers,* 3rd edition. San Francisco: A. M. Roberson, revised in 1914 and 1924.

Metcalf, Woodbridge
1924 *Growth of Eucalyptus in California Plantations, University of California Publications, College of Agriculture, Agricultural Experiment Station, Berkeley, California, Bulletin No. 380, November 1924.* Berkeley: University of California Printing Office. Available at the Helen Crocker Russell Library of Horticulture, San Francisco Botanical Garden at Strybing Arboretum.

Miley Paul Holman (Holman & Associates)
1998 Letter to Michell A. Schaeffer (Environment Coordinator, Campus Planning, UCSF), 7 May 1998. RE: Summary of Findings of the Archaeological Testing of the Proposed Handicapped Access Ramp at the Chancellor's Residence, Near the Rock Shelter Known as Ishi's Cave.

The Military Standard
2011 The Military Standard: Nike.

http://themilitarystandard.com/missile/nike/sites/sf-89-l.php (accessed 10 February 2011).

Mooser, William, Jr., Branch Manager
1938 *Report on Progress of the Works Program in San Francisco*. [San Francisco]: Works Progress Administration. January 1938. Copy in San Francisco Public Library (Call No. 917.9461 Un 38r)

Much, Bryan (Researcher I, Northwest Information Center)
2008 Memo to Maureen S. Kick (NWIC File No. 07-0842), RE: Records Search Summary Letter for Vegetation Management Project (17 January 2008) in URS Inc., *Cultural Resources Technical Report: Mount Sutro Vegetation Management, University of California, San Francisco, FEMA PDMC-PJ-09-2007-10, July 2008*, Appendix B.

Nelson, Doug
2004 *National Register of Historic Places Registration Form: Golden Gate Park, San Francisco.*

NPS. *See* United States Department of the Interior, National Park Service.

Pacific Aerial Surveys.
1935, 1938, 1948, 1955, 1958, 1961, 1969, 1972, 1979, 1983, 1989, 1993, and 2000. Aerial photographs that show the Mount Sutro area. Oakland, CA: HJW Geospatial Inc.

Pease Press Cartography
2011 [*Mount Sutro Trail Map*]. San Francisco: Pease Press Cartography. http://sutrostewards.org/page/trail-map (Accessed 10 August 2011)

Pilas-Treadway, Debbie (Native American Heritage Commission)
2007 Letter to Maureen S. Kick (URS Corporation). RE: Proposed Mount Sutro Open Space Reserve, San Francisco County, 14 December 2007 in URS, Inc., Cultural Resources Technical Report: Mount Sutro Vegetation Management . . .: Appendix D, 2008.

Postel, Maude H.
1931 *The Life Work of Adolph Sutro: An Address Made to the P. T. A. and Pupils of Sutro School, San Francisco*. [San Francisco: s.n.]

Poskanzer, Jef
2011 The Nike Missile Sites of San Francisco Bay Area. http://www.acme.com/jef/nike/ (accessed 10 February 2011).

Proctor, Jacqueline.
2006 *Images of America: San Francisco's West of Twin Peaks*. San Francisco: Arcadia Publishing.

Real Estate Data
1980 Real Estate Atlas of San Francisco, California, Aerial/Map Volume. Hayward, CA: Real Estate Data.

Rockafellar, Nancy
2001 *A History of the University of California San Francisco*. http://history.library.ucsf.edu/ (accessed 11 February 2011)

Ryder, E. S.
1896 "A Forest of Over a Million Trees in the Heart of San Francisco." *San Francisco Chronicle*, 18 October 1896: 1.

[San Francisco] Board of Park Commissioners
1872 *First Biennial Report of the San Francisco Park Commissioners, 1870-71.* San Francisco: Francis & Valentine, Steam Book and Job Printers.

1886 *The Development of Golden Gate Park and Particularly the Management and Thinning of its Forest Tree Plantations. A Statement from the Board of Park Commissioners, Together with Reports from Messrs. Wm. Ham. Hall, Consulting Civil Engineer, Fred. Law Olmsted, Landscape Architect, and John McLaren, Landscape Gardener*. San Francisco: Bacon & Company, Book and Job Printers.

[San Francisco] Board of Park Commissioners
1886 *The Development of Golden Gate Park and Particularly the Management and Thinning of its Forest Tree Plantations. A Statement from the Board of Park Commissioners, Together with Reports from Messrs. Wm. Ham. Hall, Consulting Civil Engineer, Fred. Law Olmsted, Landscape Architect, and John McLaren, Landscape Gardener*. San Francisco: Bacon & Company, Book and Job Printers.

San Francisco Chronicle.
1886 "Arbor Day; The Time of its Institution Fixed Upon at Goat Island." *San Francisco Chronicle*, 11 September 1886: 4.

1897 "Adolph Sutro's Donation." *San Francisco Chronicle*, 24 August 1897: 8.

1898 "Adolph Sutro Goes To Rest...." *San Francisco Chronicle*, 9 August 1898: 12.

1899 "Fire In Sutro's Woods Burns over Sixty Acres; Shifting Winds Fortunately Prevent Flames From Reaching the Affiliated Colleges and the Almshouse." *San Francisco Chronicle*, 9 October 1899: 10.

1904 "Where Coyotes Howl in the City Limits; This is the Only City Which includes a District of Untrodden Wilderness Inhabited by Wild Beasts." *San Francisco Chronicle*, 10 April 1904: 6.

1909 "Sutro Forest Not To Be Cut Down, But Preserved: Executrix of the Estate Says That the Timber Will Not Be Sold." *San Francisco Chronicle*, 25 March 1909: 13.

1917a "Sutro Forest Land Assessed at $137,200." *San Francisco Chronicle*, 12 August 1917: 40.

1917b "Wild Animals Hunted Around Sutro Forest; Wildcats, Raccoons and Coyotes Are Driven Out by Fire." *San Francisco Chronicle*, 22 October 1917: 15.

San Francisco Examiner.

1917 "Midnight Blaze Seen For Miles Around San Francisco." *San Francisco Examiner*, 22 October 1917.

Santos, Robert LeRoy

1997 *The Eucalyptus of California: Seed of Good or Seeds of Evil?* DeNair, California: Alley-Cass Publications, 1997. http://wwwlibrary.csustan.edu/bsantos/euctoc.htm (accessed 13 May 2008).

Schnieder, Daniel (Film Maker and Local Historian)

2009a Email to Judy deReus, 31 July 2009. RE: FEMA—Fire History (includes "Sutro Forest FIRE History" an unpublished chronology forwarded by Diane Wong, 3 December 2010).

2009b Email to Judy deReus, 3 August 2009. RE: FEMA—Fire History (includes info on Nike site and logging forwarded by Diane Wong, 3 December 2010).

2011 Telephone and email communication with Denise Bradley, February 18 and 25.

Scolari, Paul
1999 Personal communication to Steve Haller, GGNRA Park Historian. Cited in Denise Bradley and Michael Corbett, National Register of Historic Places Registration Form: Sutro Historic Landscape District, San Francisco, CA, Draft, 1999.

Sexton, Ella M.
1900 Ten Picnics For A Dollar For The Stay-At-Homes Who Must Pass The Summer In Town. *San Francisco Chronicle*, 24 June 1900: 27.

Shinn, Charles H.
1878 *Pacific Rural Handbook*. San Francisco: Charles H. Shinn.

Silver, Mae
2001 *Rancho San Miguel: a San Francisco Neighborhood History*. San Francisco: Ord Street Press.

Spider Dance Media
2010 The Sutro Stewards: An Urban Trail Story in San Francisco. http://sutrostewards.org/video/the-sutro-stewards-an-urban (accessed 10 February 2011).

Stewart, Robert and Mary Frances Stewart
1962 *Adolph Sutro, A Biography*. Berkeley, CA: Howell-North.

Streatfield, David C.
1976 "The Evolution of the Southern California Landscape, 1. Settling into Arcadia," *Landscape Architecture* (January 1976): 39, 42, 44-46, 78.

1985 "Where Pine and Palm Meet: The California Garden as a Regional Expression," in *Landscape Journal*, 4, 2 (Fall 1985): 63-74.

1994 *California Gardens: Creating a New Eden*. New York: Abbeville Press.

Strong, Elisabeth Haight.
1910 Four Miles of Wilderness in a City of Half a Million People; Sutro Forest Home of Coyotes, Wildcats, Foxes, Badgers, Raccoons, Weasels, Civits. *San Francisco Chronicle*, 27 November 1910: 3.

Sutro, Adolph
1895 *Adolph Sutro's Letter to the Regents of the University of California and to the Committee of Affiliated Colleges on the Selection of a Site for the Affiliated Colleges, 5 September 1995*. [San Francisco: n.p.]

Sutro Stewards
2011 Mount Sutro History. http://sutrostewards.org/ (accessed 10 February 2011)

Thompson, Erwin N.
1979 *Historic Resource Study: Seacoast Fortifications San Francisco Harbor, Golden Gate National Recreation Area, California*. Denver: Denver Service Center, Historic Preservation Team, National Park Service.

Trulsen, E. G.
1942 [Feature on Editorial page]. *San Francisco Chronicle*, 14 January 1942. Referenced in Craig Dawson email 30 July 2009.

UCSF. *See* University of California San Francisco.

Ungaretti, Lorri
2003 Images of America: San Francisco's Sunset District. San Francisco: Arcadia Publishing.

United Railways
1925 *San Francisco [route map]*. San Francisco: United Railways.

1930 *San Francisco [route map]*. San Francisco: United Railways.

United States Coast & Geodetic Survey
1886 *San Francisco Entrance, California: 1884*. Washington, D.C.: U.S. Coast & Geodetic Survey. Available University California, Berkeley Earth Sciences Library Map Room.

United States Department of the Interior, Geological Survey (USGS)
1895, 1898, 1914, 1942, 1946, 1948 *San Francisco, Calif*. [Quadrangle]. Topographic map, 15-minute series (scale 1:62,500).

1947, 1950, 1956, 1968, 1993, 1995 *San Francisco North, Calif*. [Quadrangle]. Topographic map, 7.5-minute series (scale 1:24,000).

United States Department of the Interior, National Park Service (NPS)
n.d *National Register Bulletin 18: How to Evaluate and Nominate Designed Historic Landscapes*. Prepared by J. Timothy Keller and Genevieve P. Keller. http://www.cr.nps.gov/nr/publications/bulletins/nrb18/ (accessed 10 February 2011).

1996 The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes. Edited by Charles A. Birnbaum with Christine Capella Peters. Washington, D.C: NPS.

1998 *A Guide to Cultural Landscape Reports: Contents, Process, and Techniques*. Prepared by Robert R. Page, Cathy A. Gilbert, and Susan A. Dolan. Washington, D.C.: NPS, 1998.

1999 *National Register Bulletin 30: How to Evaluate and Document Rural Historic Landscapes*. Prepared in 1989 by Linda Flint McClelland, J. Timothy Keller, ASLA, Genevieve P. Keller, and Robert Z. Melnick, ASLA. Revised in 1999. Washington, D.C.: NPS. http://www.cr.nps.gov/nr/publications/bulletins/nrb30/ (accessed 30 January 2011)

2002 *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*. Prepared by the staff of the National Register of Historic Places, finalized by Patrick W. Andrus, edited by Rebecca H. Shrimpton, 1990, Revised 1991, 1995, 1997,Revised for Internet 1995, 2001, 2002. Washington, D. C.: NPS. http://www.nps.gov/history/nr/publications/bulletins/nrb15/ (accessed 30 January 2011)

2011 The Secretary of the Interiors' Historic Preservation Professional Qualifications Standards: Historical Landscape Architects. http://www.nps.gov/history/local-law/gis/html/quals.html (accessed 8 August 2011).

University of California, Berkeley, Earth Sciences Library

1945, 1946 (Air Photo GS-CP), 1965 (Air Photo 17), 1974 Map Room Aerial Photograph Collection

University of California, San Francisco.

2010a *UCSF Mount Sutro Open Space Reserve Community Planning Process Summary Report, November 2010*.

2010b *Notice of Preparation / Initial Study: University of California San Francisco, Mount Sutro Management, 10 December 2010.*

URS, Inc.

2008 Cultural Resources Technical Report: Mount Sutro Vegetation Management, University of California, San Francisco, FEMA PDMC-PJ-09-2007-10, July 2008. Prepared for FEMA, U.S. Department of Homeland Security, Oakland, CA.

USGS. *See* United States Department of the Interior, Geological Survey.

Vieno, J. Edwin

1909 Consolidated Eucalyptus Co. Explains Sutro Timber Contract. *San Francisco Chronicle*, 27 March 1909: 7.

Woodbridge, Sally B.

2006 *San Francisco In Maps & Views*. New York: Rizzoli International Publications, Inc.

Young, John P.
1914 Scarcity in the Midst of Plenty. *San Francisco Chronicle*, 14 June 1914: 30.

Young, Terence
2004 *Building San Francisco's Parks, 1850-1930.* Baltimore, MD and London: The Johns Hopkins University Press.

Zito, Kelly
2011 "Interior Greenbelt Park at top of Mt. Sutro open." *San Francisco Chronicle*, 12 June 2011: D-1.

## APPENDIX

**Figure 1:** Project Site

**Figure 2:** Mount Sutro Open Space Reserve

**Figures 3 to 19:** Historical Images

**Figures 20 to 50:** Photographs of Existing Conditions

**Figure 51:** Proposed Demonstration Project Areas

**Figure 52:** Proposed Trails

**Figure 1: UCSF Campus Sites**
**Project Site – Parnassus Heights**

Source: UCSF Campus Planning

1 Parnassus Heights
2 Mission Bay
3 Mount Zion
4 Laurel Heights
5 Buchanan Dental Clinic
6 Mission Center Building
7 654 Minnesota Street
8 Hunters Point
9 Oyster Point
10 San Francisco General Hospital (Affiliation)
11 Veterans Affairs Medical Center (Affiliation)
12 185 Berry Street
13 50 Beale Street
14 220 Montgomery Street
15 1930 Market Street
16 982 Mission Street
17 2300 Harrison Street
18 2727 Mariposa Street
19 3360 Geary Boulevard
20 250 Executive Park Boulevard

**Figure 2: Mount Sutro Open Space Reserve**

Source: UCSF Campus Planning

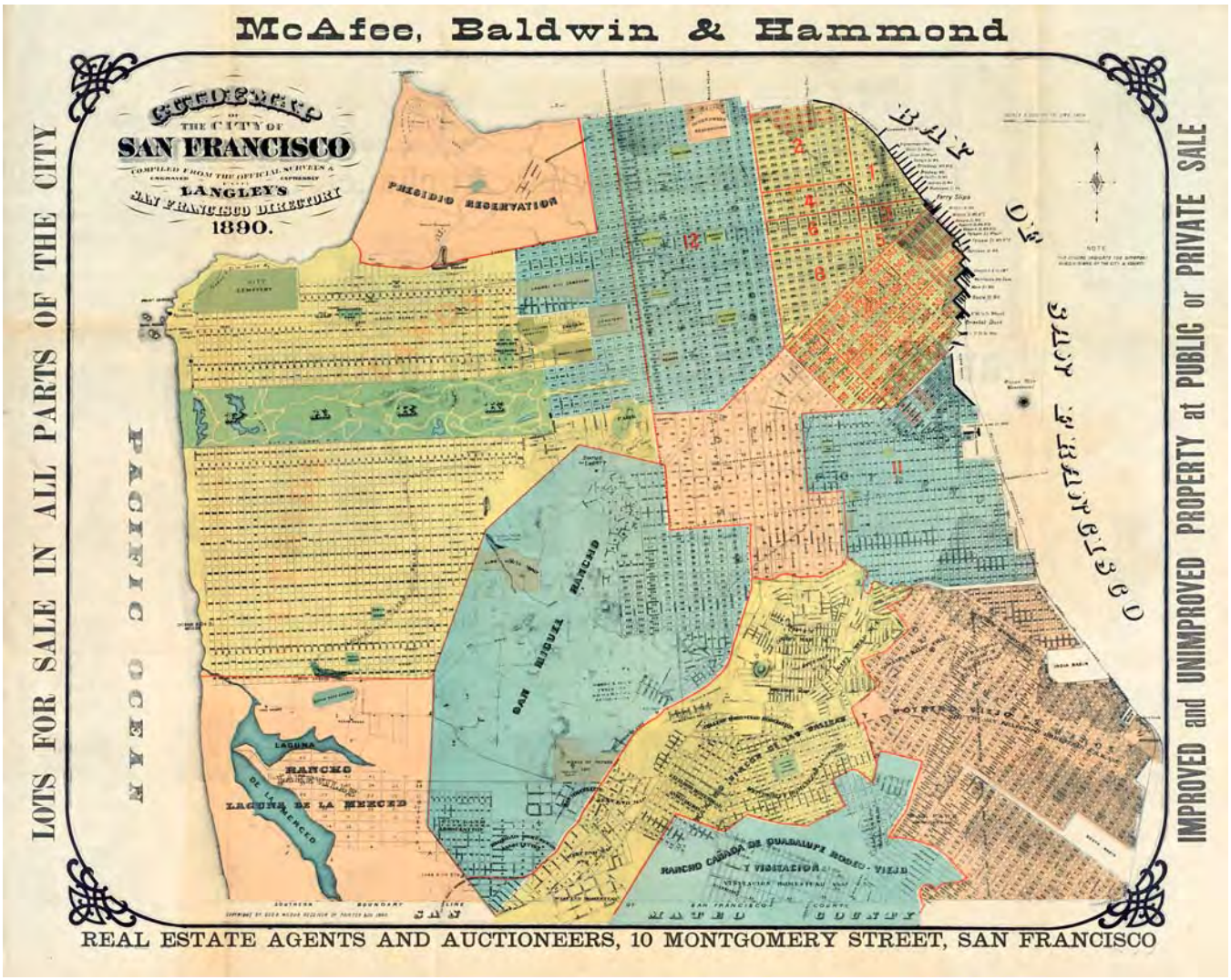



Figure 3. Langley's 1890 Guide Map to the City of San Francisco (Source: David Rumsey Maps). San Miguel Rancho tract shown in blue in the center of the map. Mount Sutro not labeled.

Figure 4. View of the north side of the Mount Sutro cultural landscape along Parnassus Avenue.

(a) No. 51 in Baldwin's 1910 Appraisal of Sutro's Estate. "Standing on the Knoll on Block 745 to the north of Parnassus Avenue, looking southwesterly across Parnassus Avenue towards the Sutro Forest and Affiliated Colleges" (Source: San Francisco History Center, San Francisco Public Library).

(b) Current view along Parnassus Avenue.

Figure 5. View of the east side of the Mount Sutro cultural landscape along Stanyan Street.

(a) No. 43 in Baldwin's 1910 Appraisal of Sutro's Estate. "Sutro Addition. Standing on the easterly side of Stanyan Street at Rivoli Street, looking south up Stanyan Street, showing lots on the easterly side of Stanyan Street" (Source: San Francisco History Center, San Francisco Public Library).

(b) Current view along Stanyan Street at Rivoli Street.

Figure 6. View of the east side of the Mount Sutro cultural landscape.

(a) No. 45 in Baldwin's 1910 Appraisal of Sutro's Estate. "Sutro Addition. Standing on the easterly side of Stanyan Street, just south of 17th, looking across Stanyan Street at lots on the westerly side, showing Eucalyptus trees in lots and house to the south" (Source: San Francisco History Center, San Francisco Public Library).

(b) Current view along Stanyan Street at 17th Street. Car on the west side of the street is parked in front of the house shown in the 1910 photograph (house is hidden behind the sweet gum tree).

Figure 7. View of the east side of the Sutro Forest looking north along Stanyan Street.

Figure 8. View of the forest edge on the north side of Mount Sutro cultural landscape along Woodland Avenue.

(a) No. 46 in Baldwin's 1910 Appraisal of Sutro's Estate. "Sutro Addition. Standing on the east side of Belmont Avenue, looking south at Woodland Avenue, lots in Block A" (Source: San Francisco History Center, San Francisco Public Library).

(b) Current view from Willard Street (formerly Belmont) south to Woodland Avenue.

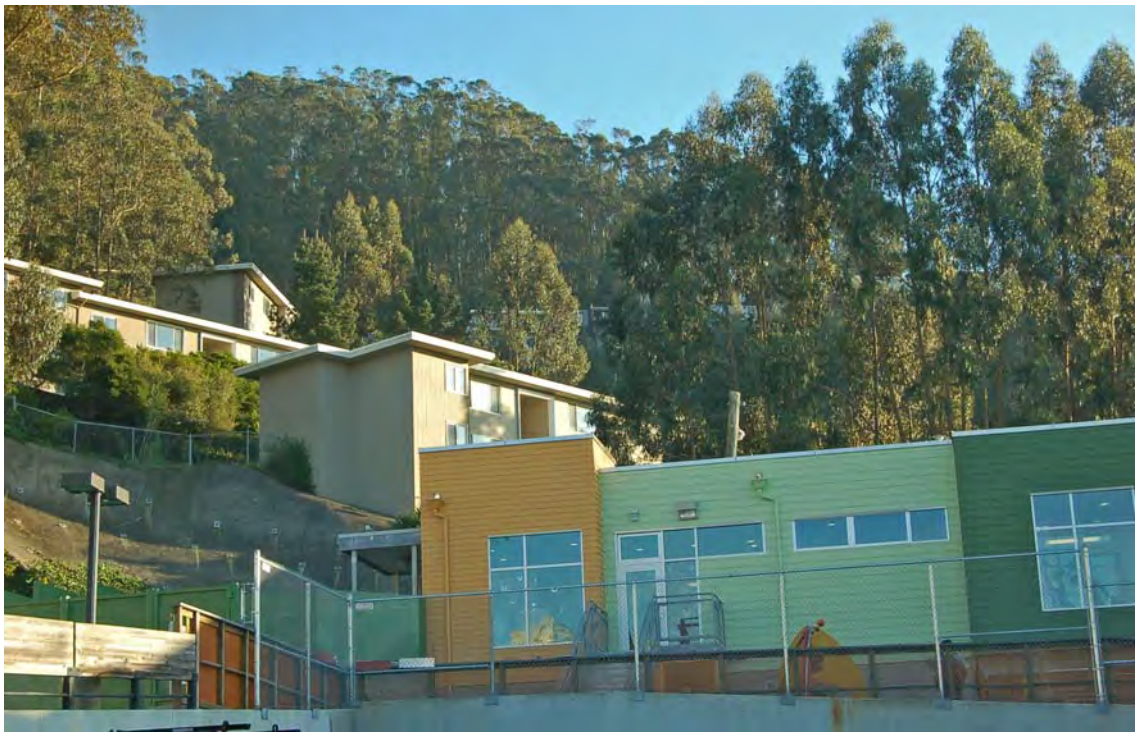
Figure 9. View of the forest edge on the north side of the Mount Sutro cultural landscape along Edgewood Avenue.

(a) No. 47 in Baldwin's 1910 Appraisal of Sutro's Estate. "Sunset Heights. Standing on the east side of Edgewood Avenue, looking south at Gore Lot No. 42 and lots 30 and 31, Block H, Sunset Heights owned by Sutro Estate" (Source: San Francisco History Center, San Francisco Public Library).

(b) Current view south along Edgewood Avenue.

Figure 10. View of the forest edge along the west side of the Mount Sutro cultural landscape.

(a) No. 52 in Baldwin's 1910 Appraisal of Sutro's Estate. "Forest Tract. Standing on the east side of 5th Avenue, north of K Street, looking southwest towards 7th Avenue… showing Sutro land with and without forest" (Source: San Francisco History Center, San Francisco Public Library).



(b) Current view from UCSF in the vicinity of 4th and 5th Avenue near Kirkham Street.

Figure 11. Current views to the west side of the Mount Sutro cultural landscape area.

Figure 12. View of the forest in the vicinity of Laguna Honda.

(a) No. 54 in Baldwin's 1910 Appraisal of Sutro's Estate. "Forest Tract. Standing on the hillside between 7th and 8th Avenues and Noriega (N) Street and Ortega (O) Street, opposite Lake Honda Reservoir, looking across the lake towards the lower gate entrance to the forest tract. A beautiful and easy approach to the Sutro property if the reservoir could be eliminated" (Source: San Francisco History Center, San Francisco Public Library).

(b) Current view to the southeast of Laguna Honda.

Figure 13. View of the south side of the Mount Sutro cultural landscape area.

a) No. 55 in Baldwin's 1910 Appraisal of Sutro's Estate. "Forest Tract. Clarendon Avenue Entrance " (Source: San Francisco History Center, San Francisco Public Library).

(b) Current view of Forest Knolls that was built along the southwest and south slopes of Mount Sutro in the late 1950s and early 1960s.

Figure 14. Aerial view in 1935 (Source: HJWgeospatial/Pacific Aerial Surveys). Note the extent of logging operations and existing trails.

Figure 15. Aerial view in 1955 (Source: HJWgeospatial/Pacific Aerial Surveys). Note the Nike facility at the summit, new road connecting the summit to Clarendon, clear cutting south of the summit, and addition of Medical Center Way in the north.

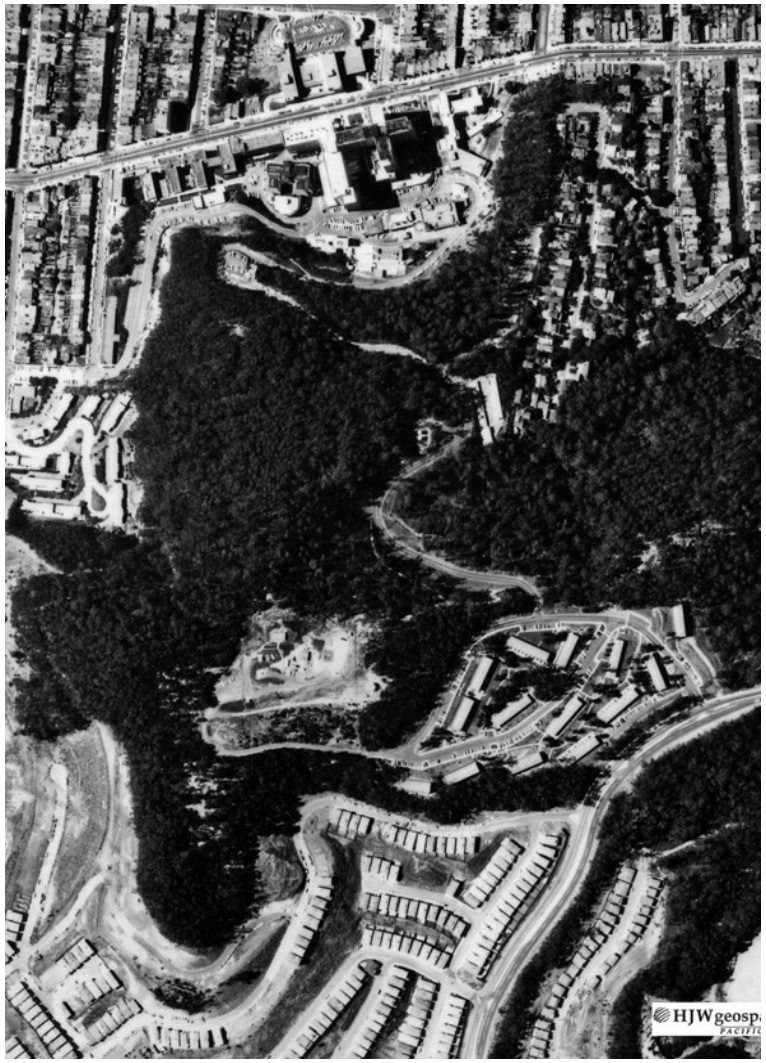



Figure 16. Aerial view in 1961 (Source: HJWgeospatial/Pacific Aerial Surveys). Note the Aldea housing complex, completion of Medical Center Way to Clarendon Avenue, and construction of Forest Knolls along the south and southwest slopes.

Figure 17. Aerial view in 1977 (Source: HJWgeospatial/Pacific Aerial Surveys). Note the removal of the Nike structures at the summit and the addition of the Chancellor's residence.

Figure 18. Extent of Sutro Forest in the vicinity of Mount Sutro in 1946 (Source: US Geological Survey on Google Earth).

Figure 19. Extent of Sutro Forest in the vicinity of Mount Sutro in 1987 (Source: US Geological Survey on Google Earth).

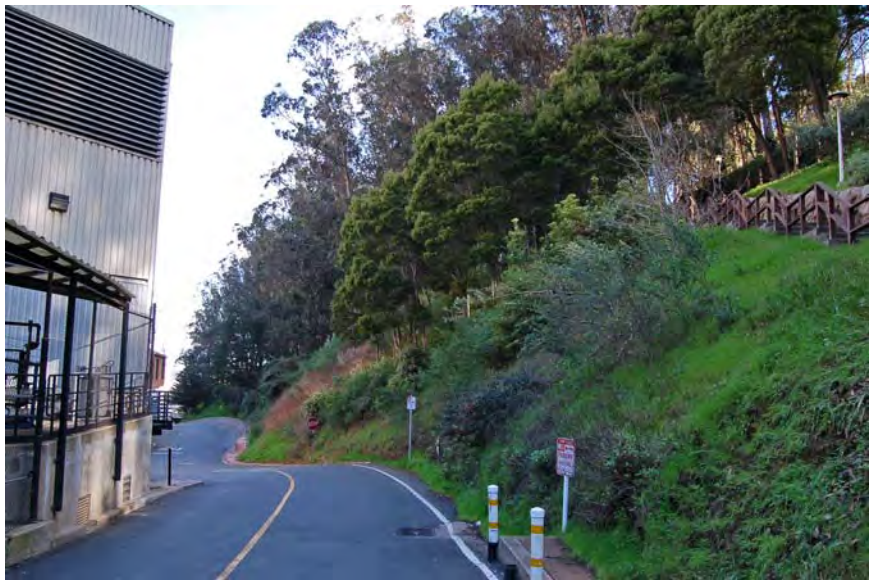


Figure 20. Boundary of Mount Sutro Open Space Reserve on north side (view to east along Medical Center Way).

Figure 21. Boundary of Mount Sutro Open Space Reserve on north side (view southwest up Medical Center Way).

Figure 22. Boundary of Mount Sutro Open Space Reserve on north side (view southwest along at Koret Way).

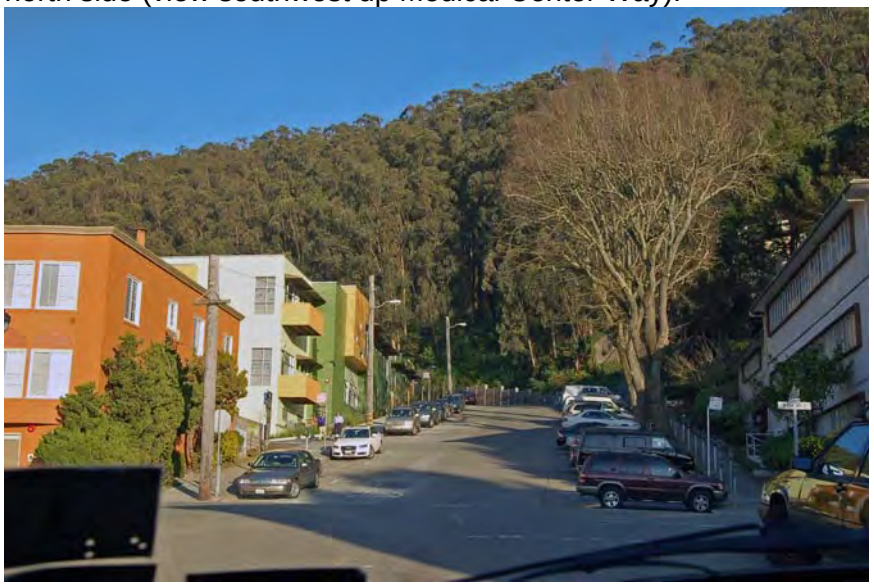


Figure 23. Boundary of Mount Sutro Open Space Reserve on north side (view east on Kirkham Street at 5th Avenue).

Figure 24. Boundary of Mount Sutro Open Space Reserve on west side (view north on Crestmont Drive).

Figure 25. Boundary of Mount Sutro Open Space Reserve on south side (view west on Christopher Drive).

Figure 26. Medical Center Way creates an internal boundary within the Reserve (view southeast on Medical Center Way).

Figure 27. View south east on Medical Center Way. Note the major cut in the slope on the right (west) side of road that has been stabilized with concrete.

Figure 28. View west on Nike Road.

Figure 29. View west on unpaved road below summit that leads to water tank.

Figure 30. View east on unpaved road toward water tank.

Figure 31. View east on Farnsworth Street toward the Farnsworth Trailhead.

Figure 32. View north along the East Boundary Trail.

Figure 33. View southwest along the Farnsworth Trail (a branch trail off the East Boundary Trail) that leads down to the Parnassus campus.

Figure 34. Connection to the Farnsworth Trail and Surge Lot at Medical Center Way.

Figure 35. Historic Trail.

Figure 36. Historic Trail.

Figure 37. Rock outcrop along Historic Trail.

Figure 38. Rock outcrop along Historic Trail.

Figure 39. North Ridge Trailhead at Medical Center Way.

Figure 40. East Ridge Trailhead at Johnstone Drive.

Figure 41. East Ridge Trail.

Figure 42. West Ridge Trailhead at Crestmont Drive.

Figure 43. South Ridge Trailhead at Christopher Drive.

Figure 44. South Ridge Trailhead at Nike Road.

Figure 45. View of Fairy Gates Trail in relation to grade of Medical Center Way.

Figure 46. View of graded bed for Fairy Gates Trail.

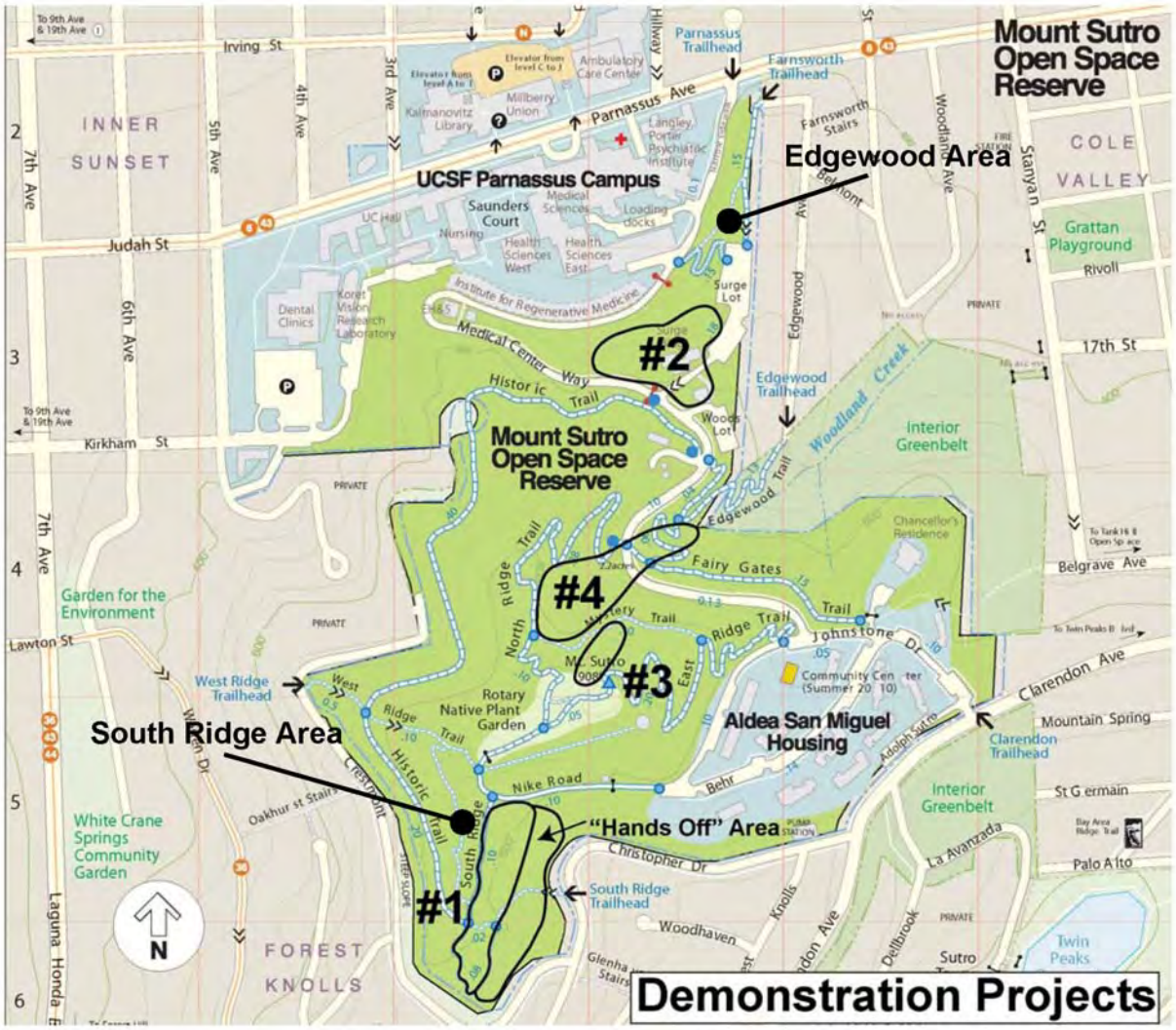
Figure 47. View of Fairy Gates Trail in relationship to rock outcropping.

Figure 48. View of rock outcroppings north of Chancellor's residence.

Figure 49. Ishi Trail area.

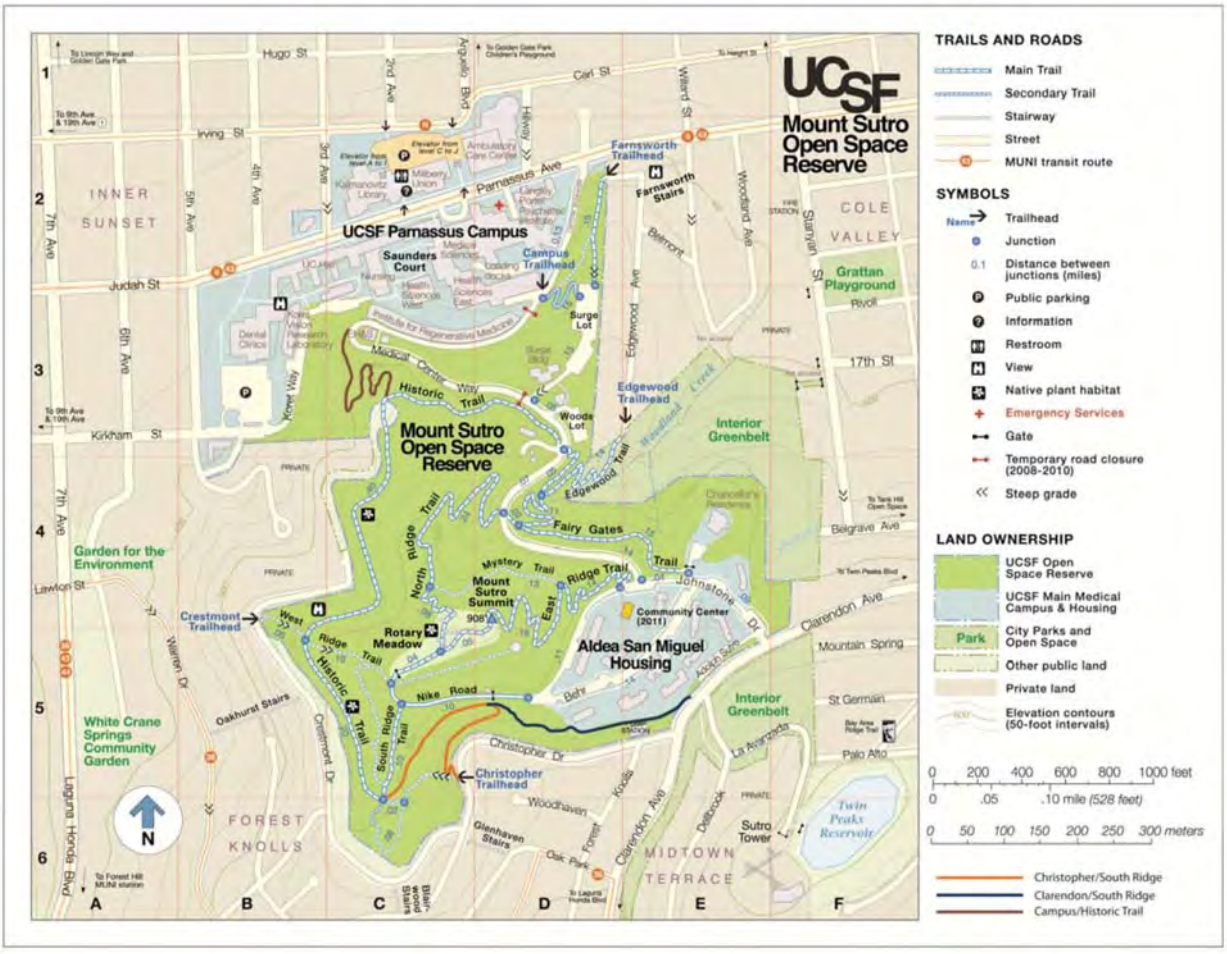
Figure 50. Limited views are visible along the trails through the existing trees.

**Figure 51: Proposed Demonstration Project Areas**




Source: UCSF Campus Planning

## Figure 52: Proposed Trails




Source: UCSF Campus Planning

# APPENDIX E

GEOLOGICAL ASSESSMENT

Final Report
Geotechnical and Geological Evaluation

# UCSF Mount Sutro Management

San Francisco, California

January 7, 2013
#2011-048G

Rutherford + Chekene
55 Second Street, Suite 600
San Francisco, CA 94105

#

# Final Report

# Geotechnical and Geological Evaluation
# UCSF Mount Sutro Management
# San Francisco, California

January 7, 2013

January 7, 2013

Diane Wong
Senior Planner/Environmental Coordinator
UCSF Campus Planning
654 Minnesota Street
San Francisco, CA 94143-0286

2011-048G

Subject: **FINAL REPORT**
**GEOTECHNICAL AND GEOLOGICAL EVALUATION**
**UCSF MOUNT SUTRO MANAGEMENT**
**SAN FRANCISCO, CALIFORNIA**

Dear Ms. Wong:

We are very pleased to send you a copy of our final report containing the findings of the subject evaluation that covered the Mount Sutro Open Space Reserve. Our scope of work is contained in our proposal, dated April 18, 2011.

This project was completed by a team consisting of Rutherford + Chekene as the prime consultant, and Geoinsite as the Engineering Geology subconsultant to Rutherford + Chekene.

Haneberg Geoscience also provided some input on the enclosed maps as the LiDAR processing subconsultant to Rutherford + Chekene.

Technical review of the maps was provided by Rutherford + Chekene and Geoinsite and field reconnaissance of the campus was performed by Geoinsite and Rutherford + Chekene.

If there are questions regarding any aspect of this evaluation, please contact us. We appreciate the opportunity to be of service to you on this most interesting project.

Sincerely,

RUTHERFORD + CHEKENE

Gyimah Kasali, Ph.D, P.E., G.E
Principal

William F. Cole, C.E.G
Geoinsite, Inc.

# TABLE OF CONTENTS

**Topic** **Page No.**

Letter of Transmittal
Table of Contents ..... i
List of Figures ..... ii
List of Tables ..... ii
List of Maps ..... ii
Executive Summary ..... iii

**INTRODUCTION ..... 1**

General ..... 1
Background ..... 1
Limitations ..... 2

**METHODOLOGY ..... 3**

Summary ..... 3

**SITE HISTORY RELATING TO SLOPE STABILITY ..... 4**

Previous Studies ..... 4
History of Slope Failures ..... 4

**LiDAR DATA COLLECTION AND PROCESSING ..... 6**

LiDAR Data Collection ..... 6
LiDAR Data Processing and Mapping ..... 6
*Topographic Contour Map (Map 1)* ..... *6*
*Engineering Geologic Map (Map 2)* ..... *7*
*Qualitative Slope Hazard Map (Map 3)* ..... *8*

**DISCUSSION ..... 9**

Thinning of the Forest ..... 9
Minor Trails ..... 9

**REFERENCES ..... 10**

**APPENDICES**

**APPENDIX A**
Figures

**APPENDIX B**
Tables

**APPENDIX C**
LiDAR-Based Maps

## LIST OF FIGURES


| Figure No. | Title | Page No. |
|---|---|---|
| 1 | Site Vicinity Map with LiDAR Survey Boundaries | A1 |
| 2 | Locations of Four Historical Buildings at UCSF | A2 |
| 3 | Locations of Previous Slope Failures | A3 |


## LIST OF TABLES


| Table No. | Title | Page No. |
|---|---|---|
| Table 1 | Locations and Descriptions of Previous Slope Failures | B1-B3 |
| Table 2 | Standards for High Resolution LiDAR Data | B4 |


## LIST OF MAPS


| Map No. | Title | Page No. |
|---|---|---|
| 1 | LiDAR-Based Topographic 5-Foot Contour Map | M1 |
| 2 | LiDAR-Based Engineering Geologic Map | M2 |
| 3 | LiDAR-Based Qualitative Slope Hazard Map | M3 |

## EXECUTIVE SUMMARY

We reviewed the proposed long-term management plan for the Mount Sutro Open Space Reserve with a focus on the aspect of the plan involving the thinning of the forest and construction of minor trails.

We evaluated the potential impacts of the plan on the stability of the slopes and potential for erosion. Our approach involved an initial review of previous documents pertaining to the slopes in the open space reserve. The primary document that we reviewed was a report that we published in 2006 about campus-wide slope stability evaluation for the University of California San Francisco (UCSF) Parnassus campus. Following the review, we reconnoitered the site to assess the changes (if any) that had occurred since our last site reconnaissance in 2006. Finally, we revisited the qualitative slope stability evaluation that we had performed using LiDAR data during our 2006 evaluation.

Based on the preceding, we have concluded that there is no immediate impact on slope stability due to the thinning of the forest or construction of minor trails as proposed. We have also concluded that the potential impact of the proposed thinning of the forest on erosion of the slopes is low. The only proposed activity that has the potential to impact erosion in the short term and the stability of affected slopes in the long term is the minor trail construction, but that potential impact can be mitigated by following best management practices in the construction and maintenance of those trails.

Historical landslide records on the UCSF campus indicate that control of surface runoff is the most important factor in minimizing the potential for slope stability problems on the campus or in the open space reserve. For that reason, best management practices that are implemented must include the following, in addition to other typical practices found in such documents as the Handbook for Forest and Ranch Roads:

1. Trails involving cuts must not be located along the toe of steep (greater than 2 horizontal to 1 vertical) slopes.

2. Cuts must be made in such a way that surface runoff is directed upslope into swales or drainage structures rather than down slope.

3. Fill or cut slopes must be vegetated to minimize the potential for erosion.

4. A geotechnical engineer should be commissioned to review plans for trails for potential impacts on erosion and long term slope stability before the trails are constructed.

5. Periodic review of trails should be carried out during the first year of construction so that evidence of potential erosion can be detected early and remedial action can be taken immediately.

# INTRODUCTION

## General

This report contains the findings of the slope stability-related evaluation that we performed for the Mount Sutro Open Space Reserve. The reserve is part of the larger University of California San Francisco (UCSF) Parnassus Heights Campus in San Francisco, California. The reserve occupies 61-acres of the larger campus and covers the largely undeveloped and steep portions of the campus. The site location is shown in Figure 1, Site Vicinity Map, in Appendix A.

The evaluation was aimed at qualitatively assessing the potential for slope stability and erosion hazards in the Mount Sutro Open Space Reserve in the context of the proposed long range development plan for the reserve.

## Background

We understand that Campus Planning is considering a plan to implement a portion of the long range development plan (LRDP) for the Mount Sutro Open Space Reserve ("Open Space Reserve"). The LRDP includes a proposal to investigate an appropriate maintenance and restoration program for trees and vegetation in the reserve. The Mount Sutro Open Space Reserve Management Plan, which was prepared in 2001 as part of the effort to fulfill this proposal, was meant to serve as a framework for future management activities. The plan identified five near-term management actions that could be implemented within about 10 years. Some of these actions have already been implemented.

Although the management plan continues to serve as a guide, specific plans for management continue to evolve. One of the recent specific projects would involve the implementation of a number of management activities, including the thinning of the forest, native plant restoration and enhancement and conversion planting, as well as the construction of minor trails. Of particular importance to the planning process are the potential impacts of the thinning of the forest and the construction of minor trails on slope stability and erosion hazards in the Open Space Reserve.

We understand that the forest thinning activities will be based on the following general criteria:

1. Trees classified as dead, diseased, structurally deficient, unhealthy, or hazardous by the Project Arborist will be removed.

2. Removal will also be based on a targeted overall spacing of 30 or 60 feet between remaining trees that are either less than or equal to 12 inches in diameter or are greater than 12 inches in diameter.

3. Trees that are removed will be cut flush to the ground and the intent is to leave the roots in place to the extent practicable.

## Limitations

Our services consist of professional opinions and recommendations made in accordance with generally accepted engineering geology principles and practices. No warranty, expressed or implied, or merchantability of fitness, is made or intended in connection with our work, by the proposal for consulting or other services, or by the furnishing of oral or written reports or findings. This report has been prepared in order to provide our client with a qualitative evaluation of the proposed forest thinning plan identified herein. Evaluations of other geotechnical hazards or conditions are beyond the scope of this investigation.

## METHODOLOGY

### Summary

Our evaluation was based on the following:

1. Review of historical documents pertaining to slope stability issues in the Open Space Reserve.

2. Observations made during our site reconnaissance of the Open Space Reserve.

3. Revisit of the 2006 UCSF campus-wide slope stability evaluation that was based on the analysis of LiDAR data.

The evaluation, which was made in the context of the proposed forest management activities in the Open Space Reserve, was aimed at assessing both the potential immediate and long term impacts of the proposed management activities on the stability and potential for erosion of the slopes in the Open Space Reserve.

We initiated our data gathering process by meeting with the Project Arborist at the beginning of our reconnaissance visit to the Open Space Reserve. The Project Arborist gave us a briefing on the criteria for selection and removal of trees.

We understand that our findings will be combined with the findings of other disciplines involved in the evaluation of various factors that could impact the sustenance of the Open Space Reserve.

## SITE HISTORY RELATING TO SLOPE STABILITY

### Previous Studies

The general geology of San Francisco is described in innumerable maps and reports, both published and unpublished. The Parnassus campus lies in the San Francisco North 7.5' quadrangle, which was mapped by Schlocker (1974) and is included in the more recent regional map compiled by Blake *et al* (2000).

The region is characterized by bedrock knobs and hills that protrude through younger, Quaternary-age alluvium and dune sand. The Open Space Reserve is underlain by Franciscan Complex bedrock (chert, greenstone and meta-sandstone and shale). Bedrock occurs at or very near the ground surface throughout much of the area, but locally is overlain by surficial materials (colluvium and shallow landslides) within drainages that have developed along mountain flanks.

Wilson *et al* (2000) conducted a seismic slope stability hazard analysis of San Francisco and noted several landslides in the Open Space Reserve, but do not appear to have collected detailed information on the Open Space Reserve.

Rutherford + Chekene have performed a number of pre- and post-occurrence landslide studies in various areas of the Open Space Reserve. Rutherford & Chekene (1999) performed a campus-wide slope stability evaluation based on: 1) a review of such existing documents as topographical maps, boundary surveys, aerial photographs, geologic reports, and geologic maps, and 2) field reconnaissance of the campus. This evaluation was limited to the areas in the immediate vicinity of the developed portions of the campus. Rutherford & Chekene (2006) again performed a campus-wide slope stability evaluation covering the entire campus this time because of the availability of LiDAR data. The review and field reconnaissance exercises undertaken during 1999 and 2006 resulted in the development of a map of potentially unstable areas.

Notable pieces of historical information used in that 2006 evaluation included borehole logs and unpublished reports on file at Rutherford + Chekene, most notably a series of short reports by Marliave (1948 a,b,c; 1951) and Woodward Lundgren & Associates (1974a, 1974b, and 1974c).

The primary conclusion from the Rutherford + Chekene slope stability evaluation is that surface runoff control is the most important factor in minimizing the potential for slope stability and erosion problems on the UCSF campus.

### History of Slope Failures

Eyewitness type accounts of the effects of the 1906 earthquake on the campus are contained in a document called "Tales and Traditions", compiled by Dr. W.E Carter. Although there was no reference to seismic-induced landslides or slope failures in the vicinity of the then-existing buildings (shown in Figure 2), it should be noted that the focus of the report was on the performance of the existing buildings. The only reported damage was a vertical crack observed in the auditorium wall of the building housing the College of Medical Science. The crack was

attributed to the erosion of sand in the vicinity of the building foundation by the then-existing Hayes Creek, which flowed downhill in the northerly direction on the eastern side of the College of Medical Science.

Reports about slope failures appeared to have coincided with the construction of roads and new buildings to the south, east and west of the then-existing buildings shown in Figure 2. The first reference to a slope failure was in a 1948 report by Marliave, which alluded to a failure along the then-cut slope to the southeast of the existing Langley Porter Clinic, but this failure was not attributed to an earthquake. The approximate location of this slope failure is shown as S3 in Figure 3 in Appendix A.

During our 2006 study we compiled a list of historical slope failures on the larger UCSF campus. The approximate locations of those slope failures are shown in Figure 3. Brief descriptions of each of the previous slope failures at the time they were mapped are presented in Table 1 in Appendix B.

## LiDAR DATA COLLECTION AND PROCESSING

### LiDAR Data Collection

The topographic data on which the Rutherford & Chekene (2006) work was based were collected using Light Detection and Ranging (LiDAR), also known as airborne laser scanning and airborne laser swath mapping, to produce a high-resolution digital elevation model (DEM) that could be used as the basis for both qualitative and quantitative maps useful for the delineation of potential slope hazards. The ability of LiDAR technology to create reliable and practically useful high-resolution digital elevation models (DEMs) of land covered by dense forests has been proven in the Puget Sound region of Washington; along the northern portion of the San Andreas Fault in Sonoma and Mendocino Counties, California; in Humboldt County, California; in Papua New Guinea; and in many other areas.

LiDAR data for the project were collected in November 2005 by Airborne 1 of El Segundo, California, as part of a speculative project to obtain standard resolution LiDAR coverage of San Francisco. To provide the data for this project, the company collected approximately 1000 acres of high resolution LiDAR data covering the UCSF campus with vertical accuracy conforming to National Standard for Spatial Data Accuracy (NSSDA) and Federal Emergency Management Agency (FEMA) standards as shown for high resolution data in Table 2 in Appendix B. The horizontal accuracy guaranteed by Airborne 1 was ±1 foot standard deviation. Compliance was documented using ground control obtained by a qualified surveyor under contract to Airborne 1.

The LiDAR data were supplied to Rutherford + Chekene as ASCII text files containing the xyz coordinates (often referred to as a point cloud) and laser return intensity values converted from the original WGS84 coordinates to the California State Plane Coordinate System (U.S. survey feet, NAD83 HARN horizontal datum, NAVD88 vertical datum).

### LiDAR Data Processing and Mapping

The collected LiDAR data were processed by first creating a Digital Elevation Model (DEM) from which various maps were derived. Maps resulting from the LiDAR data processing are presented in Appendix C. The maps are described as follows:

#### *Topographic Contour Map (Map 1)*

The DEM was contoured at a 5-foot interval for slope hazard mapping using the terrain analysis software LandSerf version 2.2. Although the high-resolution LiDAR data collected for this project will nominally support a 1-foot contour interval, a 5-foot interval was more appropriate for the identification of potential slope hazards on the campus-wide scale used for the 2006 evaluation.

***Engineering Geologic Map (Map 2)***

The engineering geologic map was created by integrating the DEM and its derivatives with field-based observations of geologic conditions. Following preliminary processing of the LiDAR data, fieldwork took place over two days in May 2006 and the map was finalized in the office to allow the use of digital mapping techniques such as the superposition of engineering geologic information with the shaded relief, slope angle, roughness, and contour maps.

Soil and rock types are shown on the engineering geologic map using the Unified Engineering Geologic Mapping System (Keaton and DeGraff, 1996), with vertical series of soil or rock types used to indicate the stratigraphic sequence of map units. Other features relevant to the project– for example, areas of slow soil creep, landslides, and rock outcrops— are indicated as shown on the map. Much of the area shown as chert (CH) on the engineering geologic map is overlain by thin soil, but outcrops are common and the soil thickness is not likely to exceed a few feet. Thus, the thin soil over chert was not shown as a separate unit on the map. Although features that may be indicative of potential future instability (for example old landslides or areas undergoing soil creep) are shown, the engineering geologic map does not contain information about hazards evaluation.

Most of the bedrock exposed in the reserve is folded and thinly bedded red and green chert of the Franciscan Complex. A small area of sandstone occurs in the northwestern portion of the UCSF campus south of Parnassus Avenue. In the few locations where strike and dip directions could be measured in the tightly folded to wavy chert beds, the orientations represent average conditions. The relatively young sediments of the Colma Formation were encountered in previous subsurface geotechnical borings, but the formation is not exposed on the ground surface in the reserve.

The engineering geologic map shows a possible ancient landslide occupying much of the area between Parnassus Avenue and Medical Center Way, beneath the most highly developed portion of the UCSF campus. Identification of this feature is tentative because naturally occurring landforms indicative of landsliding have been largely destroyed by development. The large bowl-shaped feature, information from borehole logs on file at Rutherford + Chekene, and a bedrock bulge from the Woodward Lundgren & Associates (1974) geologic investigation suggest that the area may be underlain by a large landslide, perhaps involving Franciscan bedrock, of old but uncertain age.

The possibility of a large ancient landslide in this highly developed area was raised by Marliave (1948c), but was discounted in later investigations by Woodward Lundgren & Associates (1974a, 1974b, and 1974c) based primarily on the latter's contention that the northward sloping sedimentary strata encountered at the Moffitt Hospital modernization project were continuous and that they bore no resemblance to chaotic strata that had been identified by others to be associated with massive ancient landslides in the region. This ancient landslide area is mostly outside the boundaries of the Open Space Reserve.

***Qualitative Slope Hazard Map (Map 3)***

The qualitative slope hazard map is an interpretive map that combines the information shown on the engineering geologic map (Map 2), the cut and fill slope map, which is not included in this report, and field observations recorded by geo-professionals to depict areas in which slope instability is most likely to occur. Areas with signs of very recent or imminent movement are shown in red, whereas areas with the potential for future movement as a consequence of heavy rain and/or seismic shaking are shown in yellow and orange.

The large possible ancient landslide shown on the engineering geology map is categorized as stable on the qualitative slope hazard map because it appears to be buried and/or buttressed by younger sediments and this investigation yielded no surficial signs of recent movement. This project did not, however, include a quantitative stability evaluation of the possible landslide and the potential for future movement during a major earthquake is unknown.

## DISCUSSION

### Thinning of the Forest

The proposed thinning of the forest will be dictated by the criteria governing that activity as established by the Project Arborist. As previously noted in this report, trees will be selected for removal if they are dead, diseased, structurally deficient, unhealthy or hazardous. More importantly, if removed, the trees will be cut flush to the ground and the roots left in place. The stabilizing characteristics of a tree stem from its root system. In this case, the stabilizing characteristics of the removed tree are retained until the roots rot completely. The qualitative slope stability evaluation of the site is therefore not adversely impacted by the thinning of the forest.

### Minor Trails

Proposed trails are likely to involve minor cutting or filling. Any earthwork, however minor, would usually result in the exposure of soils that would be inherently susceptible to erosion. Left unchecked, even minor erosion could lead to long term slope stability problems. Implementation of erosion control measures involving the use of vegetation on exposed slopes should therefore be an integral part of the design and construction of the minor trails.

Historical records indicate that the presence of water is the common factor in all the previous slope failures that have occurred on the larger UCSF Parnassus campus. None of the more than a dozen slope failures have been linked to an earthquake. Control of water, especially from surface runoff is therefore the most important factor in minimizing the potential for slope stability and erosion problems. Surface runoff should be directed towards swales on the upslope side of the trail.

Other factors to consider in the design, construction, and maintenance of the trails include the following:

1. Cut slopes associated with the trails should be located in such a way as to avoid undermining the stability of the toe of existing slopes.

2. The design of proposed trails should be reviewed by a geotechnical engineer in the context of its potential impact on slope stability and erosion hazards.

3. The trail should be reviewed periodically during the first year of construction and remedial action should be taken to address any evidence of erosion.

4. Best management practices from such documents as the Handbook for Forest and Ranch Roads should be incorporated into the design, construction and maintenance of the trails.

## REFERENCES


1. Barnett, P.J., Singhroy, V.H., Shirota, J., and Leney, S.J., 2004, Methods for remote engineering geology terrain analysis in boreal forest regions of Ontario, Canada: *Environmental & Engineering Geoscience*, v.10, p. 229-241.

2. Blake, M.C., Graymer, R.W., and Jones, D.L., 2000, *Geologic map and map database of parts of Marin, San Francisco, Alameda, Contra Costa, and Sonoma Counties, California*: U. S. Geological Survey, Miscellaneous Field Studies Map MF-2337.

3. California Division of Mines and Geology, 1997, *Guidelines for Evaluating and Mitigating Seismic Hazards in California*: CDMG Special Publication 117, 74 pp.

4. Hammond, C., Hall, D., Miller, S., and Swetik, P., 1992, *Level I Stability Analysis (LISA) Documentation for Version 2.0*: U.S. Forest Service, Intermountain Research Station General Technical Report INT-285, 190 pp.

5. Haneberg, W.C., submitted, Elevation errors in a LiDAR digital elevation model of West Seattle and their effects on slope stability calculations, *in* R.L. Baum, J. Godt, and L. Highland, editors, *Landslides and Engineering Geology of the Greater Seattle Area, Washington*: Geological Society of America Reviews in Engineering Geology.

6. Haneberg, W.C., in press, Effects of digital elevation model errors on spatially distributed seismic slope stability calculations: an example from Seattle, Washington: *Environmental & Engineering Geoscience*.

7. Haneberg, W.C., 2006, *PISA-m: Map-Based Probabilistic Infinite Slope Analysis, Version 1.0 User Manual:* Seattle, Washington, Haneberg Geoscience, 20 pp.

8. Haneberg, W.C., 2004, A rational probabilistic method for spatially distributed landslide hazard assessment: *Environmental & Engineering Geoscience*, v. 10, p. 23-47.

9. Haneberg, W.C., 2000, Deterministic and probabilistic approaches to geologic hazard assessment: *Environmental & Engineering Geoscience*, v. 6, p. 209-226.

10. Haneberg, W.C., Creighton, A.L., Medley, E.W., and Jonas, D.A., 2005, Use of LiDAR to assess slope hazards at the Lihir gold mine, Papua New Guinea, in O. Hungr, R. Fell, R. Couture, and E. Eberhardt, editors, *Landslide Risk Management*: Proceedings of International Conference on Landslide Risk Management, Vancouver, Canada, 31 May - 3 June, 2005, Supplementary CD.

11. Jibson, R.W., Harp, E.L., and Michael, J.A., 2000, A method for producing digital probabilistic seismic landslide hazard maps: *Engineering Geology*, v. 58, p. 271-289.

12. Jibson, R.W. and Jibson, M.W., 2003, *Java Programs for Using Newmark's Method and Simplified Decoupled Analysis to Model Slope Performance During Earthquakes (Version 1.1)*: U.S. Geological Survey Open-File Report 03-005 (CD-ROM).

13. Keaton, J.R. and DeGraff, J.V., 1996, Surface observation and geologic mapping, *in* A.K. Turner and R.L. Schuster, editors, *Landslides, Investigation and Mitigation*: Transportation Research Board Special Report 247, pp. 178-230.

14. Marliave, C., 1948a, Letter to R.A. Weaver dated 5/14/48.

15. Marliave, C. 1948b, Letter to R.A. Weaver dated 6/16/48.

16. Marliave, C., 1948c, Letter to R.A. Weaver dated 11/22/48.

17. Marliave, C., 1951, Letter to R.S. Gould dated 2/2/51.

18. McKean, J. and Roering, J., 2004, Objective landslide detection and surface morphology mapping using high-resolution airborne laser altimetry: *Geomorphology*, v. 57, p. 331-351.

19. Newmark, N.M., 1965, Effects of earthquakes on dams and embankments: *Geotechnique*, v. 15, p. 139-160.

20. Rutherford & Chekene, 1999, *Phase 1 Report, Slope Stability Evaluation, Parnassus Campus, University of California, San Francisco, California*, February.

21. Rutherford & Chekene, 2002, *Sutro Landslide, University of California, San Francisco, California*, July 18.

22. Rutherford & Chekene, 2006, *Slope Stability Risk Assessment, University of California, San Francisco, California*, August 25.

23. Schlocker, J., 1974, *Geology of the San Francisco North Quadrangle, California*: U.S. Geological Survey Professional Paper 782.

24. Weaver, W.E. and Hagans, D.K., 1994, Handbook for Forest and Ranch Roads, June.

25. Wilson, R.I., Wiegers, M.O., and McCrink, T.P., 2000, Earthquake-induced landslide evaluation report, *in Seismic Hazard Zone Report for the City and County of San Francisco, California*: California Division of Mines and Geology Seismic Hazard Zone Report 043, pp. 19-39.

26. Woodward Lundgren & Associates, 1974, *Geologic and Seismologic Investigation, H. C. Moffitt Hospital Modernization, University of California Medical Center, San Francisco, California*, April.

27. Woodward Lundgren & Associates, 1974, *Geotechnical Investigation for the Proposed H. C. Moffitt Hospital Modernization, University of California Medical Center, San Francisco, California*, July.

28. Woodward Lundgren & Associates, 1974, *Supplemental Geotechnical Investigation, H. C. Moffitt Hospital Modernization, University of California Medical Center, San Francisco, California*, December.

# APPENDIX A
## Figures

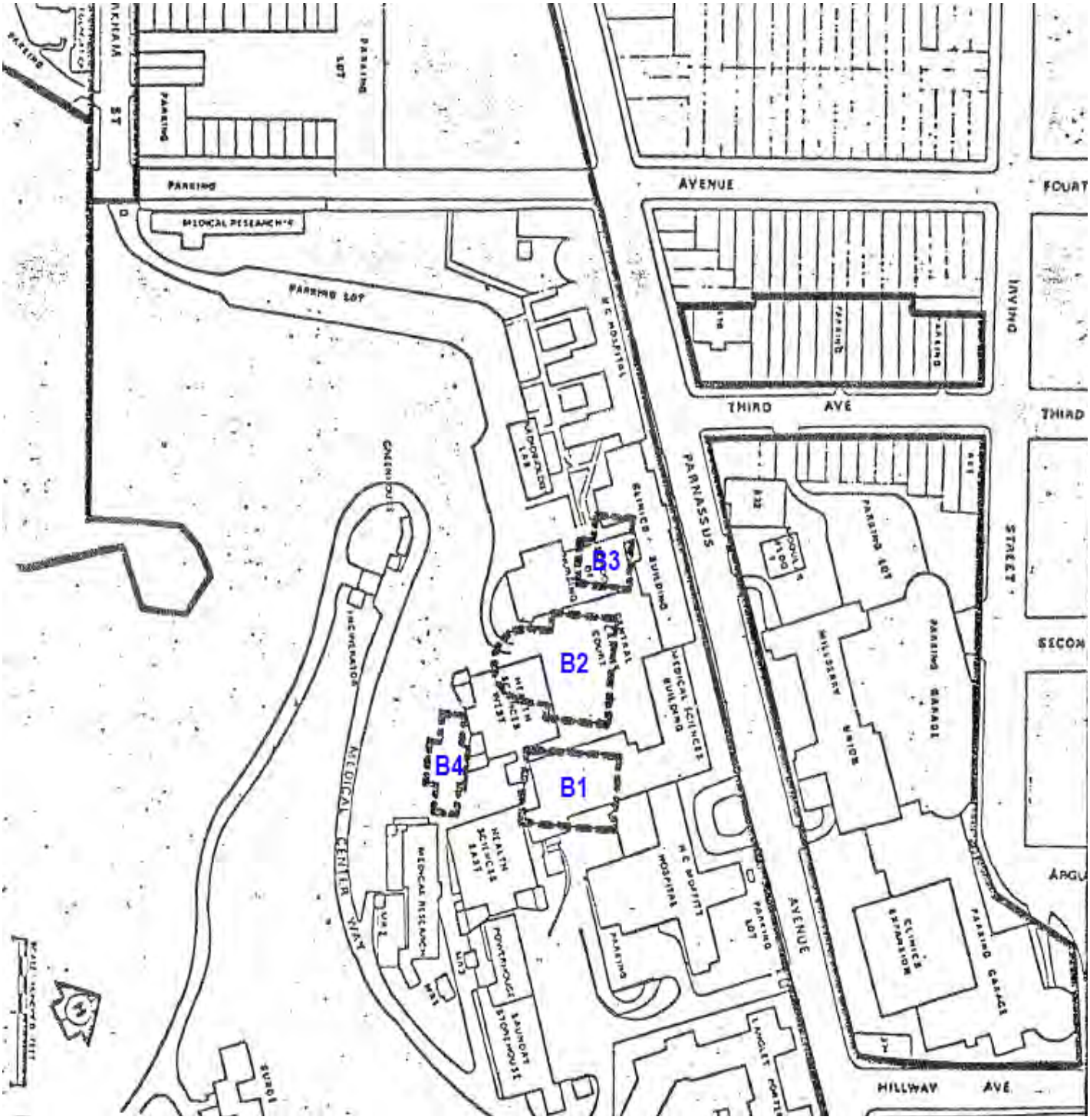
RUTHERFORD + CHEKENE
Structural | Geotechnical Engineers
55 Second Street Suite 600
San Francisco CA 94105
T 415 568 4400
F 415 618 0684
www.ruthchek.com

# Site Vicinity Map with LiDAR Survey Boundaries

Geotechnical and Geological Evaluation

UCSF Mount Sutro Management, San Francisco, California

| JOB NUMBER | DATE | FIGURE | PAGE |
|---|---|---|---|
| 2011-048G | 1/7/2013 | 1 | A1 |




B1 - College of Pharmacy

B2 - College of Medical Science

B3 - Museum of Anthropology

B4 - College of Veterinary Science

RUTHERFORD + CHEKENE

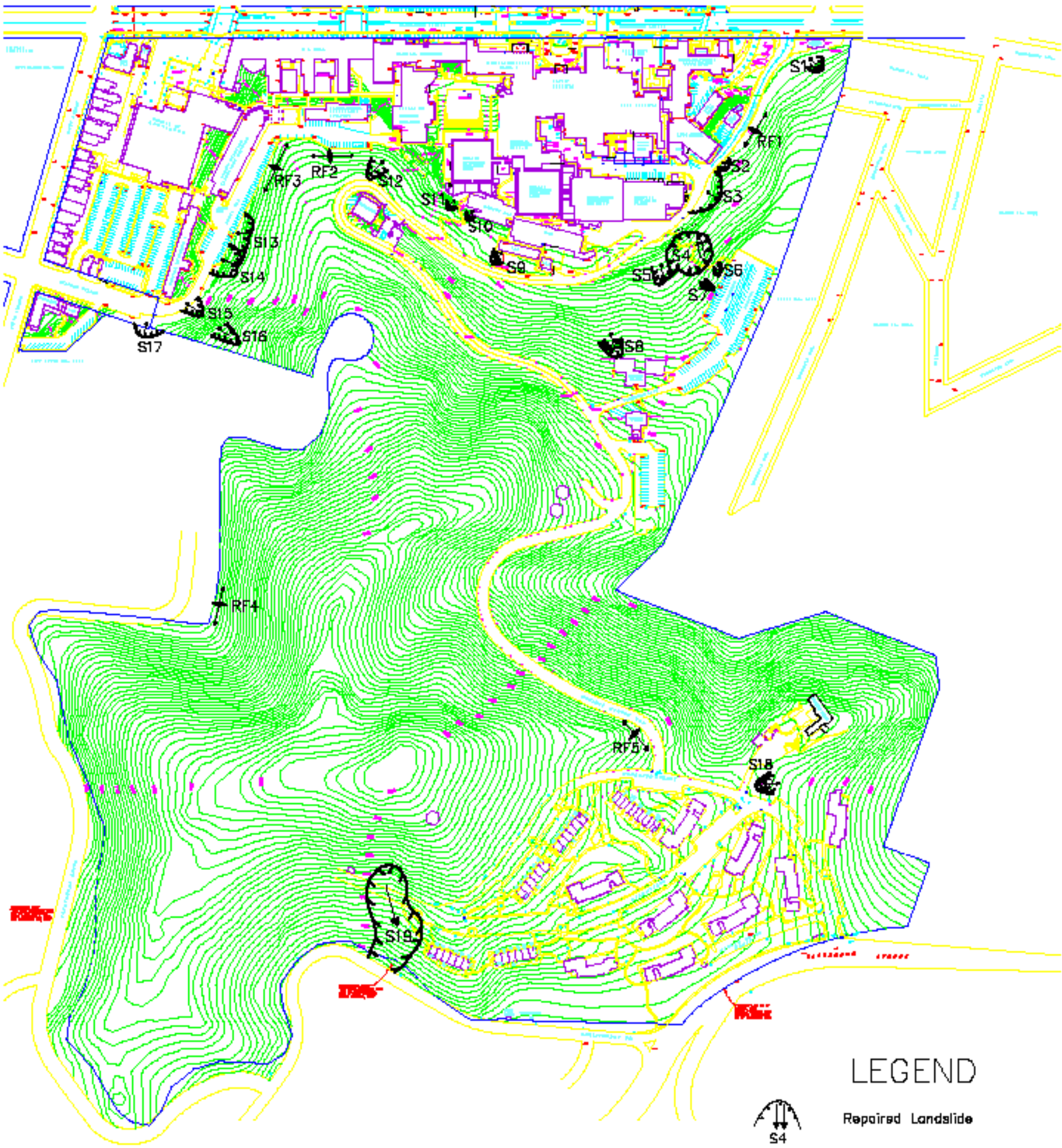
Structural | Geotechnical Engineers
55 Second Street Suite 600
San Francisco CA 94105
T 415 568 4400
F 415 618 0684
www.ruthchek.com

# Locations of Four Historical Buildings at UCSF

Geotechnical and Geological Evaluation

UCSF Mount Sutro Management, San Francisco, California

| JOB NUMBER | DATE | FIGURE | PAGE |
|---|---|---|---|
| 2011-048G | 1/7/2013 | 2 | A2 |




## LEGEND

S4 — Repaired Landslide

S1 — Approximate Location of Landslide Scarp

RF1 — Approximate Location of Rock Fall

Note: Refer to Table 1 in Appendix B for Descriptions of Identified Slope Failures


RUTHERFORD + CHEKENE

Structural | Geotechnical Engineers
55 Second Street Suite 600
San Francisco CA 94105
T 415 568 4400
F 415 618 0684
www.ruthchek.com


**Locations of Previous Slope Failures**

Geotechnical and Geological Evaluation

UCSF Mount Sutro Management, San Francisco, California

| JOB NUMBER | DATE | FIGURE | PAGE |
|---|---|---|---|
| 2011-048G | 1/7/2013 | 3 | A3 |

# APPENDIX B
## Tables

## Table 1: Locations and Descriptions of Previous Slope Failures

| Location Number | Description | Reference |
|---|---|---|
| S1 | Location S1 is a steep slope cut with a 1:1 gradient facing to the northwest. The slope has a near-vertical scarp surface at the top suggesting an earlier slope failure. The slope is composed of thinly bedded chert bedrock and is covered with some small tree plantings. At least one of the trees is bowed near the base suggesting creep movement of the slope. The bedding of the rock face is irregular and folded but dips mostly 18 to 20 degrees to the northwest, daylighting with the face of the slope.<br><br>There is a small debris fence some 15 to 20 feet upslope from the base, and a taller fence with a 3-foot wooden post and lagging wall at the base of the slope cut. The fences and wall do not show signs of leaning or other distress but they appear to have been installed very recently. There is a small utility building at the base of the slope.<br><br>The significant features of the slope are the scarp surface and bedding orientation of the chert bedrock with respect to the slope face. The bedding planes of the rock have low shear strength and the rock is fractured near vertical to the bedding. The slope is therefore highly prone to raveling with a potential for larger rock slides. Several 1- to 4-inch rock fragments have fallen to the base of the slope. | Rutheford & Chekene (1999) |
| S2 | The slide area numbered S2 is a small slump failure consisting of a mixture of clay, sand, and rock fragments. The colluvium soils became saturated and slid during the heavy rains of 1998. The slide was reported by John Burton as part of Rutherford + Chekene's observation report dated 20 February 1998. The remaining debris will continue to creep or possibly slide more rapidly onto the roadway in the coming rainy season. As previously described, concentrated surface runoff and groundwater flow from the parking lot above may have contributed to the slope failure. | Rutheford & Chekene (1999) |
| S3 | The slope numbered S3 is a moderately steep slope cut exposing mostly weathered chert with some greenstone at the base. The slope is circular-shaped with a steepened grade along its upper boundary. The upper edge may be a scarp marking an older landslide, possibly destabilized by the road cut. The vegetation consists of vines and bushes with an abundance of twigs and other organic debris matted to the surface as a result of heavy drainage flows. We observed groundwater weeping from the slope and heavy runoff at the time of our 1998 February observation reconnaissance after heavy rains. In addition, groundwater was seen upwelling from a trench patch within Medical Center Way adjacent to the slope, indicating significant groundwater discharge at the base of the slope. This landslide was observed in a 1983 aerial photograph. | Rutheford & Chekene (1999) |
| S4 | The slope failure numbered S4 is also known as the Sutro Landslide. The landslide which occurred at 11 PM on Thursday, August 2, 2001, might have resulted from rotational failure of the middle portion of the slope. The head scarp was near vertical and up to 15 feet high. The toe of the landslide was thrust out over the lower slope towards Medical Center Way and rested on the pre-existing ground surface. Subsequent failure of the toe bulge deposited debris onto the road. The interpreted daylight line of the slide was based on locations of ground water seeps and patches of apparent in-place vegetation. The slide mass was comprised primarily of colluvium and vegetative debris. One of the borings on the slope appeared to have encountered siltstone/shale within the lower portion of the slide mass. Inclusion of bedrock within the slide mass indicates that the basal failure surface probably follow weak zones in the bedrock. The landslide was repaired in 2003, using a combination of removal, recompaction and regarding in conjunction with a soil nail wall at the headscarp and a subdrainage system. | Rutheford & Chekene (2002) |
| S5 | This is an irregular, well-vegetated scarp that was observed after the 2001 Sutro Landslide. This feature is believed to be the headscarp of an older landslide, and, consequently, the area downhill of the scarp is considered as landslide deposit. The asphalt-lined V-ditch crosses this landslide and shows no indication of offset. Therefore this landslide would have had to occur prior to 1958, the date of the first aerial photograph in which the V-ditch was visible. | Rutheford & Chekene (2002) |

## Table 1: Locations and Descriptions of Previous Slope Failures (cont'd)

| Location Number | Description | Reference |
|---|---|---|
| S6 | This is an irregular, well-vegetated scarp that was observed after the 2001 Sutro Landslide. This feature is believed to be the headscarp of an older landslide, and, consequently, the area downhill of the scarp is considered as landslide deposit. The asphalt-lined V-ditch crosses this landslide and shows no indication of offset. Therefore this landslide would have had to occur prior to 1958, the date of the first aerial photograph in which the V-ditch was visible. | Rutheford & Chekene (2002) |
| S7 | This is an irregular, well-vegetated scarp that was observed after the 2001 Sutro Landslide. This feature is believed to be the headscarp of an older landslide, and, consequently, the area downhill of the scarp is considered as landslide deposit. The asphalt-lined V-ditch crosses this landslide and shows no indication of offset. Therefore this landslide would have had to occur prior to 1958, the date of the first aerial photograph in which the V-ditch was visible. | Rutheford & Chekene (2002) |
| S8 | The topographic feature at Location S8 appears to be the scarp of an older landslide. The scarp is overgrown with vines and appears as a circular steepened slope near the northwest corner of the existing Surge Building. The surrounding area is gently sloping and overgrown with vines and trees. There are a few larger trees at the head of the scarp that do not show signs of creep or recent movement. | Rutheford & Chekene (1999) |
| S9 | This is an old headscarp observed during the 1998 site reconnaissance. | |
| S10 | This is the mud flow that occurred on 3 January 2006. The mud flow resulted from surface runoff caused by a blocked drain inlet near the pump house. | |
| S11 | The base of the hill near the southwest corner of the Health Sciences Building West is a cut slope some 10 to 15 feet high, exposing a mixture of clay and chert rock fragments. The slope has had smaller failures during the past rainy season and some loose debris has accumulated at the base of the slope near the stairs. The hill above appears to be mostly weathered bedrock that may have ravelled loose rock and colluvial debris in the past. | Rutheford & Chekene (1999) |
| S12 | Area S12 is a steep slope that appears to be composed of mostly chert bedrock. The slope has a V-shaped topographic expression that indicates it may have been an older rock wedge failure, but presently the slope appears to be stable and mostly free of surface debris. | Rutheford & Chekene (1999) |
| S13 | The slope at S13 is an older landslide described by Chester Marliave in his 1951. geologic report. The scarp face is some 60 feet wide and 3 to 5 feet high. The materials exposed by the scarp are colluvial soils consisting of clayey sand and rock fragments with some large chert boulders 2 to 3 feet in diameter. Above the scarp lies a broad heavily vegetated swale extending a considerable distance up-slope. Directly above the scarp, there is an overgrown chert outcrop flanking the swale on the north side. There are occasional large chert boulders on the surface of the swale originating from the outcrop or other sources up slope.<br>The scarp surface is susceptible to sloughing or a larger slope failure with the potential for larger boulders to become dislodged. | Rutheford & Chekene (1999) |
| S14 | The slope numbered S14 is the previous slide of 1996. The scarp and slope indicate continued erosion and sloughing of the scarp. Location S14 is a bedrock slope recently covered with eroded colluvial debris. A remedial slope stabilization and drainage repair plan was prepared by Rutherford + Chekene for the slide area. | Rutheford & Chekene (1999) |
| S15 | Location S15 is the most recent slide that occurred in February 1998. The slide occurred at the corner of the roadcut which, based on historic topographic maps, was excavated between 1949 and 1950. The base of the slide is weathered sandstone covered with loose colluvial debris. The west side of the slide is flanked by a steep outcrop of massive and more competent greenstone. The top 6. to 8 feet of the failure scarp is currently covered by overhanging vines but is likely composed of colluvium. Below the vines, the scarp exposes fractured but fairly competent sandstone or siltstone. The sandstone scarp appears to have sheared as part of the slope failure, but most of the materials involved in the slide were colluvial soils from the swale above.<br>The mudslide debris in the roadway from the February 1998 slide consisted of saturated clays, silts, and sand with some rock fragments and a least one larger boulder that came to rest at the MR-IV Building. Also, heavy seepage flowed from the bedrock near the base of the slide and heavy drainage was observed flowing out of the bowl-shaped scarp. | Rutheford & Chekene (1999) |

## Table 1: Locations and Descriptions of Previous Slope Failures (cont'd)

| Location Number | Description | Reference |
|---|---|---|
| S16 | The area shown as Location S16 is an overgrown scarp surface and fan within the broad swale some 100 feet above the scarp of the more recent major slide (Location 1). The scarp marks the head of an older slip failure, probably within colluvium. Much of this material likely slid from the swale in the most recent mudslide.<br>The swale above the major slide is densely vegetated with vines and eucalyptus trees but is a broad tributary area providing significant surface flow and groundwater discharge to the slide areas below. The runoff has the effect of weakening the colluvium in the swale as the soil becomes saturated during periods of heavy runoff. | Rutheford & Chekene (1999) |
| S17 | Location S17 is an older steeply sloping slide scarp roughly 30 feet high. The top of the slide is near vertical and has recently eroded and exposed eucalyptus tree roots. The top of the scarp is some 30 feet from the adjacent Kirkham Heights apartment buildings. The adjacent slope to the east, Location S17, is irregular and is actively eroding. There are trees at the top of the slope that are leaning and appear to be holding the top of the slope in place. A portion of the eroding slope may be off UCSF property, but the slope may have become destabilized by the old trail cut leading to the scarp of the most recent slide.<br>The trail may have been cut into the slope to access the surface drain topping the slope areas further east. The trail has since been overgrown and eroded but is currently some 2 to 3 feet wide. The slopes above the cut will likely continue to slough and erode towards the apartment building. | Rutheford & Chekene (1999) |
| S18 | This is a landslide scarp observed during the 2006 site reconnaissance in connection with the campus-wide slope hazard risk assessment. | |
| S19 | This is a landslide scarp observed during the 2006 site reconnaissance in connection with the campus-wide slope hazard risk assessment. | |
| RF1 | Location RF1 is a steep slope some 15 to 20 feet high bordering the east side of Medical Center Way off of Parnassus Avenue. The slope is composed mostly of chert bedrock and is highly prone to continual raveling of 1 to 6 inch rock fragments onto the roadway. Several rock fragments were visible along the top of the short retaining wall at the base of the slope. The bedding orientation of the rock mass, where it appears, is irregular but mostly dips to the north into a generally stable configuration with respect to the direction of slope. Because of the thinly bedded and highly fractured character of the exposure, however, the slope face will continue to ravel rock fragments onto Medical Center Way. | Rutheford & Chekene (1999) |
| RF2 | The slope condition in this area is similar to RF3. A few pieces of loose rock that were about to fall were observed during the repair of the Sutro Landslide in 2003. | |
| RF3 | The slope at Location RF3 is a steep, thinly bedded chert outcrop with a precast concrete retaining wall having a 2 to 3 foot freeboard to protect the parking spaces and roadway from rock ravel. A few loose rock fragments had accumulated at the lip of the wall, but they are not significant in number. The bedding in the slope is wavy and irregular and has some adverse dip direction daylighting with the direction of slope. The slope appears to be stable, and was reported as such by Chester Marliave in his geologic report, but should be observed for rock ravel during the rainy season.<br>Also, a loose boulder was noted above the Location RF3 slope. | |
| RF4 | This is a potential rockfall condition observed during the 2006 site reconnaissance. | |
| RF5 | This is a steep slope cut with indications of rockfall over the years. The last substantial rock failure occurred during the repair of the Sutro Landslide in 2003. | |

**Table 2: Standards for High Resolution LiDAR Data**

| Airborne 1 Resolution | Typical Flying Altitude | FEMA Contour Interval | Typical LiDAR Spot Spacing | NSSDA RMSE |
|---|---|---|---|---|
| High | 3000’ | 1.0’ | 3.3’ | 0.3' |
| Standard | 4500’ | 2.0' | 4.5' | 0.6' |
| Low | 6500’ | 3.3’ | 6.5' | 1.0' |

# APPENDIX C
## LiDAR-Based Maps

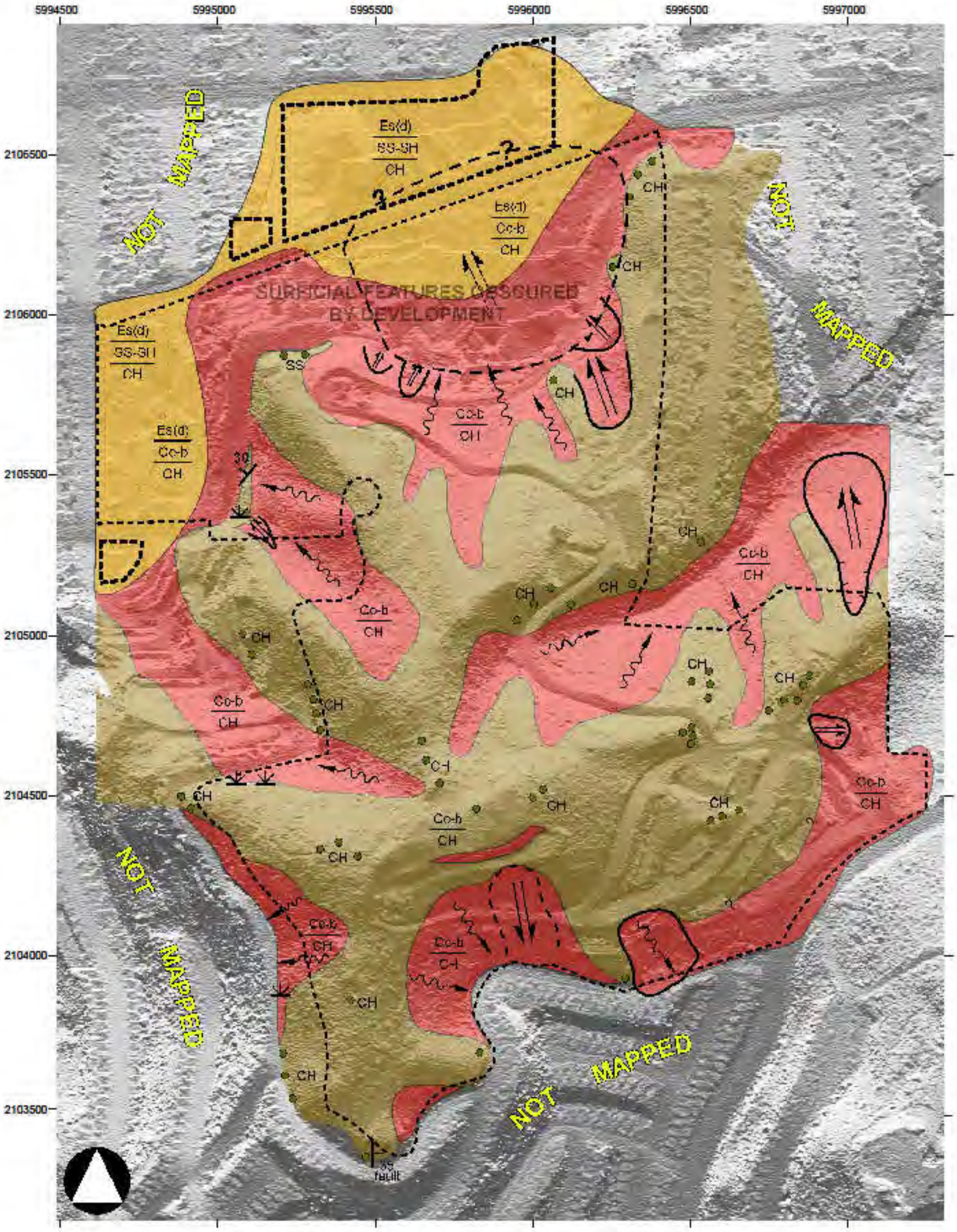
RUTHERFORD + CHEKENE
Structural | Geotechnical Engineers
55 Second Street Suite 600
San Francisco CA 94105
T 415 568 4400
F 415 618 0684
www.ruthchek.com

# LiDAR-Based Topographic 5-foot Contour Map

Geotechnical and Geological Evaluation

UCSF Mount Sutro Management, San Francisco, California

| JOB NUMBER | DATE | MAP | PAGE |
|---|---|---|---|
| 2011-048G | 1/7/2013 | 1 | M1 |





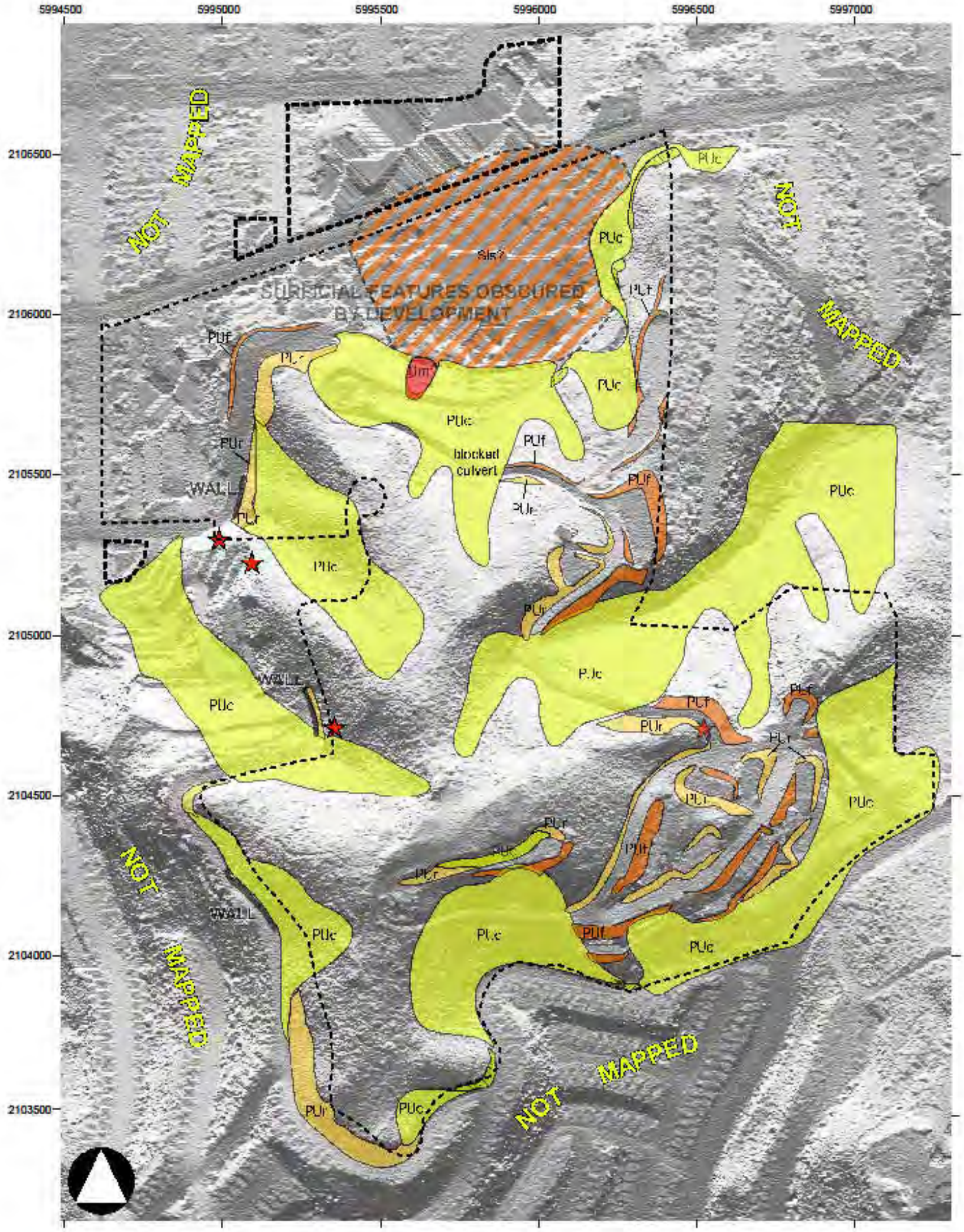
RUTHERFORD + CHEKENE
Structural | Geotechnical Engineers
55 Second Street Suite 600
San Francisco CA 94105
T 415 568 4400
F 415 618 0684
www.ruthchek.com


# LiDAR-Based Engineering Geology Map

Geotechnical and Geological Evaluation

UCSF Mount Sutro Management, San Francisco, California

| JOB NUMBER | DATE | MAP | PAGE |
|---|---|---|---|
| 2011-048G | 1/7/2013 | 2 | M2 |




Unstable with evidence of recent, current, or likely future movement (Umf). January 2006 mudflow.

Unstable with evidence of recent, current, or likely future movement (Ur). Individual boulders susceptible to movement.

Potentially unstable colluvium (PUc), in some places with evidence of ongoing soil creep and/or past landsliding. Includes oversteepened cut and fill slopes. Susceptible to landslides ten feet or more in thickness on natural slopes and rotational landslides of varying thickness in fill if disturbed by humans, shaken by earthquakes, or saturated by heavy rainfall.

Potentially unstable (PUr): Cut slopes in rock primarily susceptible to potentially damaging rock falls ranging in size from pebbles to large boulders.

Potentially unstable (PUf): Inferred fill slopes placed on rock and susceptible primarily to localized rotational landsliding with the depth of slip surfaces proportional to fill thickness.

Possible dormant landslide (Sls). Inferred on the basis of topographic expression and limited subsurface data but with no evidence for recent or current movement. Potential for future movement is uncertain. Lateral extent and depth are uncertain.

RUTHERFORD + CHEKENE
Structural | Geotechnical Engineers
55 Second Street Suite 600
San Francisco CA 94105
T 415 568 4400
F 415 618 0684
www.ruthchek.com

**LiDAR-Based Qualitative Slope Stability Map**

Geotechnical and Geological Evaluation

UCSF Mount Sutro Management, San Francisco, California

| JOB NUMBER | DATE | FIGURE | PAGE |
|---|---|---|---|
| 2011-048G | 1/7/2013 | 3 | M3 |

RUTHERFORD + CHEKENE
Geotechnical | Structural
55 Second Street, Suite 600
San Francisco, CA 94105

# APPENDIX F

GREENHOUSE GAS EMISSIONS CALCULATIONS

# Greenhouse Gas Analysis- Calculations

## Existing Conditions:

### Volume, Biomass, and Carbon Calculations

Table 1 shows the species, count, and height of trees identified within the plots. Table 2 shows wood volume, biomass, and carbon content for the forested plots in the project area. Volume, biomass, and carbon calculations are described below.

*Volume*

Volumetric values were calculated in cubic feet from DBH values using local volume equations as follows:

- Vol (cf) = a ($DBH^b$)
- Where a and b are known species-specific regression coefficients.

The following volume equations were derived from Pillsbury and Reimer (1997):

- Blue-gum eucalyptus: Vol (cf) = 0.055113 ($DBH^{2.436970}$)
- Monterey cypress: Vol (cf) = 0.035598 ($DBH^{2.495263}$)
- Blackwood acacia: Vol (cf) = 0.048490($DBH^{2.347250}$)
- *Prunus sp:* Vol (cf)= 0.030684($DBH^{2.360469}$) [1]

As logs and stumps were mostly cylindrical, volumes were calculated using DBH and length (as a proxy for height), with the equation: $V = \pi r^2 h$

*Biomass*

Live and dead standing tree biomass was converted from volumes using the United States Forest Service's (USFS) Forest Inventory Analysis (FIA) regional species-specific equations for biomass (USFS 2009), which are also used for the California Forest Protocols under AB 32. These biomass equations provide estimates for within bark stem wood and do not include the biomass of bark or branches.

Tree stem biomass was calculated from cubic volume estimates and the wood density factors as follows:

- Weight of water = 62.4 pounds/cubic foot (lbs/ft[3])

[1] The volume equation for *Liquidambar sp.* was used in lieu of a volume equation for *Prunus* sp. The two taxa are related; and a volume equation for *Prunus* is not available

- Wood density = (specific gravity) * (62.4 lbs/$ft^3$)

- Biomass of the tree stem (in tons) = (volume * wood density) / 2000

FIA's wood density values (lbs/cf) for the relevant tree species in the project area are as follows:

- For eucalyptus: 49.92
- For Monterey cypress: 21.84
- For *Prunus* sp., wood density for cherry, *Prunus cerasus*[2] was used: 29.32

Wood density values for blackwood acacia were derived from Pillsbury and Kirkley (1984), who list the specific gravity of blackwood acacia as 0.60. Wood density is then derived (e.g., for blackwood acacia wood density is 0.60 lbs/cf x 62.4 lbs/cf = 37.44 lbs/cf).

Biomass was estimated for all trees surveyed within the six plots, and then divided by 0.6 (i.e., 6 * 0.1 acre plot area) to yield an estimate of biomass per acre.

*Carbon Content*

The biomass to carbon conversion factor most commonly used is to half the biomass estimates as follows:

- Carbon content = biomass of tree stem (in tons/acre) x 0.5

Carbon estimates are presented in terms of $CO_2$ equivalent rather than carbon (C ) alone. Once carbon content was derived, the total metric tons of $CO_2$ or $CO_2e$ were calculated by multiplying carbon by 3.67, the molecular weight ratio of $CO_2$ to C (IPCC, 2007).

[2]. The *Prunus* sp. could not be identified to species; the wood density equation for *Prunus cerasus,* or cherry, was used to calculate the biomass equation for the tree.

**Table 1**: *Number of live stems, snags (dead standing), and log (fallen trees, or DWD) and number of live trees per plot*

| Plot No. | Tree species | Live Stems, Snags and Log Count | Live Tree Count |
|---|---|---|---|
| 1 | Blue-gum eucalyptus | 26 | 16 |
| | Blue-gum eucalyptus - dead standing | 1 | N/A |
| | *Prunus sp.* | 1 | 1 |
| | ***Total*** | **28** | **17** |
| 2 | Blue-gum eucalyptus | 30 | 26 |
| | *Prunus sp.* | 1 | 1 |
| | ***Total*** | **31** | **27** |
| 3 | Blue-gum eucalyptus | 21 | 21 |
| | Blue-gum eucalyptus - dead standing | 1 | N/A |
| | Blue-gum eucalyptus - DWD | 1 | N/A |
| | ***Total*** | **23** | **21** |
| 4 | Blackwood acacia | 2 | 2 |
| | Monterey cypress | 2 | 2 |
| | Blue-gum eucalyptus | 14 | 13 |
| | Blue-gum eucalyptus - DWD | 3 | N/A |
| | ***Total*** | **21** | **17** |
| 5 | Monterey cypress | 2 | 2 |
| | Blue-gum eucalyptus | 9 | 9 |
| | Blue-gum eucalyptus - DWD | 6 | N/A |
| | ***Total*** | **17** | **11** |
| 6 | Blue-gum eucalyptus | 10 | 10 |
| | *Prunus sp.* | 1 | 1 |
| | ***Total*** | **11** | **11** |
| | **Total Count** | 131 | 104 |
| | **Total/Acre** | 218.66 | 173 |

**Table 2:** *Average number of trees (live and dead) per acre; biomass, carbon content, total CO2e calculations and percent contributions CO2e to total.*

| Tree species | Average number of stems (live and dead) per acre | Biomass (tons/acre) | Carbon Content (tons/acre)* | Total $CO_2e$ (tons/acre)* | Percent Contribution $C0_2e$ to total* |
|---|---|---|---|---|---|
| Blackwood acacia (live) | 3.33 | 0.55 | 0.28 | 1.01 | 0.15% |
| Monterey cypress (live) | 6.67 | 1.30 | 0.65 | 2.39 | 0.37% |
| Blue-gum eucalyptus (live) | 183.66 | 343.71 | 171.86 | 630.71 | 98.76% |
| *Prunus sp.* (live) | 5.00 | 0.27 | 0.13 | 0.49 | 0.08% |
| Blue-gum eucalyptus (dead standing) | 3.33 | 0.81 | 0.40 | 1.48 | 0.23% |
| Blue-gum eucalyptus (dead fallen- DWD) | 16.67 | 1.37 | 0.69 | 2.51 | 0.39% |
| **Total** | **218.66** | **348.01** | **174.01** | **638.60** | **100%** |

*Due to rounding approximations, totals do not always add up exactly.

## Impact Analysis

Given the target of 30 foot spacing between trees, a 15 foot radius around each tree was assumed, such that at any point a tree has a distance of 30 feet from the next possible tree. The percentage of trees to be thinned was computed as follows:

- Projected area per tree: $\pi * r^2 = 3.14 * (15^2) = 706.5$ square feet per tree ($ft^2$/acre)
- Projected number of trees/acre: 43,560 ($ft^2$/acre)/ 706.5 ($ft^2$/acre) = 61.7 trees/acre= 62 trees/acre
- Current number of live trees/acre: 173 + dead standing trees: 2= 175 trees/acre
- Number of trees to be thinned: 175 trees/acre – 62 trees/acre = 113 trees/acre
- Percentage of trees to be thinned: 64%

Given the 113 trees/acre projected to be thinned from the current density of 175 trees per acre, and given the current capacity of the Reserve stored in live and dead standing trees is 638.6 tons $CO_2e$ /acre- 2.5 tons $CO_2e$ /acre (portion stored in dead fallen logs), or 636.1 tons $CO_2e$ /acre, the following calculations illustrate the reduction in carbon sink that will accompany live and dead standing tree thinning.

- Current carbon stored per tree = 3.63 tons $CO_2e$ per acre
- Removal of carbon sink due to thinning= 3.63 tons $CO_2e$ /tree *113 tree/acre= 410 tons $CO_2e$/acre
- Reserve-wide reduction due to thinning= 46 acres * 410 tons $CO_2e$ /acre= 18,860 tons $CO_2e$
- Total storage remaining in the Reserve post-thinning of live and dead standing trees= 38,918 tons of $CO_2e$ (current storage)- 18,860 tons $CO_2e$= 20,058 tons $CO_2e$
- Percentage loss of carbon sequestration capacity= 48%

Given that 64% of trees within the Reserve would need to be thinned to attain the target spacing, and that 55% of live trees are less than 12 inches DBH (see Section 1.1.2.2), a majority of large diameter trees would be left post-thinning. Therefore, this represents a conservative estimate of the reduction of the carbon sink under the Proposed Action; the actual reduction in live tree above-ground carbon is projected to be less than 48% of the baseline.

Factoring in the trees that would be left on-site as felled logs and mulch (see Section 2.1.1.1), the actual reduction in the Reserve's carbon sink would be further decreased. Though live trees that are felled and left on the forest floor would lose much of their carbon to the atmosphere through decomposition, some carbon would be retained. Wayburn et al (2000) estimate that up to 40% of carbon in unburned harvested wood is retained for 20 to 100 years.

Given the maximum estimate of a 48% reduction in above ground carbon:

- 60% carbon lost from harvested wood * 48% maximum reduction of carbon sequestration = 29% reduction from original carbon sequestered

- 29% * 38,918 tons of $CO_2e$ (See Existing Conditions Section XXX) = 11,286 tons of $CO_2e$ (10,239 metric tons)

Thus, a maximum of 11,286 tons of $CO_2e$ (10,239 metric tons) would be lost from the carbon sink in the Reserve under the proposed Action.

# APPENDIX G

HERBICIDE RISK ASSESSMENT

# University of California San Francisco (UCSF) Mount Sutro Herbicide Risk Assessment

## Final April 25, 2012

Susan Kegley, PhD
David Toy
Erin Conlisk, PhD
Marion Moses, MD
Michael DiBartolomeis, PhD, DABT

Pesticide Research Institute
2768 Shasta Road
Berkeley, CA 94708
E-mail: skegley@pesticideresearch.com
Phone: (510) 759-9397
Fax: (510) 848-5271
Web: www.pesticideresearch.com

## Acronyms, Abbreviations and Symbols

| | |
|---|---|
| AQUIRE | US EPA's aquatic ecotoxicity database |
| a.e. | acid equivalent, or more specifically, a carboxylic acid equivalent, characterized by the presence of a carboxyl group, -C(=O)OH. |
| a.i. | active ingredient |
| ACGIH | American Conference of Governmental Industrial Hygienists |
| AChE | acetylcholinesterase |
| AHS | Agricultural Health Study |
| AMPA | aminomethylphosphonic acid, degradation product of glyphosate |
| CA ARB | California Air Resources Board |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BCF | bioconcentration factor |
| bw | body weight |
| cm | centimeter |
| CEQA | California Environmental Quality Act |
| DBH | Diameter at breast height, a standard for measuring tree diameters |
| dose | The amount of chemical an organism has absorbed into the body. Compare to "exposure." |
| DRV | dietary reference value |
| EAD | estimated absorbed dose |
| $EC_{50}$ | the Effective Concentration of a pesticide that produces a specific measurable effect in 50 percent of the test organisms within the stated study time |
| EAD | estimated absorbed dose |
| $EC_{100}$ | the Effective Concentration of a pesticide that produces a specific measurable effect in 50 percent of the test organisms within the stated study time |
| Ecotox | US EPA's ecotoxicity database collection consisting of Terretox and Aquire databases for terrestrial and aquatic data, respectively. |
| exposure | The amount of chemical an organism has encountered in the environment through oral, dermal or inhalation routes. Compare to "dose." |
| EIR | Environmental Impact Report (CEQA) |
| EIS | Environmental Impact Statement (NEPA) |
| F | female |
| $F_0$ | parental generation in a multigenerational animal study |
| $F_1$ | first generation of offspring in a multigenerational animal study |
| FFES | Farm Family Exposure Study |
| FIFRA | Federal Insecticide, Fungicide and Rodenticide Act |
| FR | fecundity ratio, defined in Chapter 2, Section 2.2.6.B under "Fecundability" |
| FS | United States Forest Service (more commonly USFS) |
| FQPA | Food Quality Protection Act |
| g | gram |
| GLEAMS | Groundwater Loading Effects of Agricultural Management Systems |
| GM | geometric mean |
| GRAS | generally recognized as safe |
| HQ | hazard quotient |

| | |
|---|---|
| HR | hazard ratio |
| IARC | International Agency for Research on Cancer |
| IPA | isopropylamine |
| IRIS | Integrated Risk Information System |
| $K_a$ | acid dissociation constant, defined on page 2-33 of Chapter 2 |
| kg | kilogram |
| $K_{oc}$ | organic carbon partition coefficient, defined on page 2-32 of Chapter 2 |
| $K_{ow}$ | octanol-water partition coefficient, defined on page 2-32 of Chapter 2 |
| $K_p$ | skin permeability coefficient |
| L | liter |
| lb | pound |
| $LC_{50}$ | lethal concentration for 50 percent of the test organisms, defined comprehensively on page 2-26 of Chapter 2 |
| $LD_5$ | lethal dose for 5 percent of the test organisms, defined comprehensively on page 2-25 of Chapter 2 |
| $LD_{50}$ | lethal concentration for 50 percent of the test organisms, defined comprehensively on page 2-25 of Chapter 2 |
| $LD_{95}$ | lethal concentration for 95 percent of the test organisms, defined comprehensively on page 2-25 of Chapter 2 |
| LOAEC | lowest observed adverse effect concentration, defined on page 2-26 of Chapter 2 |
| LOAEL | lowest observed adverse effect level, defined on page 2-26 of Chapter 2 |
| LOC | level of concern |
| LOD | limit of detection |
| LOEC | lowest observed effect concentration |
| LOEL | lowest observed effect level |
| m | meter |
| M | male |
| MCL | maximum contaminant level |
| µg or mcg | microgram, equal to one millionth of a gram or one thousandth of a milligram |
| mg | milligram |
| mg/kg-day | milligrams of agent per kilogram of body weight per day |
| mL | milliliter |
| MRID | master record identification number |
| MS | mass spectrometry |
| MSDS | material safety data sheet |
| MW | molecular weight |
| NCI | National Cancer Institute |
| NHL | non-Hodgkins lymphoma |
| NIH | National Institutes of Health |
| NNG | N-nitrosoglyphosate |
| NOAEC | no observed adverse effect concentration |
| NOAEL | no observed adverse effect level |
| NOEC | no observed effect concentration |
| NOEL | no observed effect level |
| NPE | nonylphenol polyethoxylate |
| NRC | National Research Council |

| | |
|---|---|
| NTP | National Toxicology Program |
| NTD | neural tube defect |
| OFFHS | Ontario Farm Family Health Study |
| OPP | Office of Pesticide Programs |
| OR | odds ratio, defined on page 2-22 of Chapter 2 |
| OSHA | Occupational Safety and Health Administration |
| PAD | population adjusted dose, similar to a reference dose, but often contains an additional uncertainty factor for vulnerable populations. |
| PEL | permissible exposure limit |
| PHED | Pesticide Handler's Exposure Database |
| PHG | public health goal |
| PISP | Pesticide Illness Surveillance Program (CA) |
| pKa | negative logarithm of a chemical's acid dissociation constant |
| POEA | polyoxyethyleneamine, a surfactant used in Roundup products |
| PPE | personal protective equipment (e.g., gloves, boots, goggles) |
| ppm | parts per million |
| RBC | red blood cells |
| RED | US EPA reregistration eligibility decision |
| RfD | reference dose, the dose below which no adverse effects are anticipated for humans |
| RTU | ready to use |
| RR | relative risk or rate ratio |
| SD | standard deviation |
| SCE | sister chromatid exchange |
| SENSOR | Sentinel Event Notification System of Occupational Risk |
| SERA | Syracuse Environmental Research Associates |
| TCP | 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr |
| TMP | 3,5,6-trichloro-2-methoxypyridine, degradation product of triclopyr |
| Terretox | US EPA's terrestrial ecotoxicity database |
| TESS | Toxic Exposure Surveillance System |
| TLV | threshold limit value |
| TRV | Toxicity Reference Value, the dose below which no adverse effects are anticipated in a wildlife population |
| UF | uncertainty factor |
| US | United States |
| US EPA | United States Environmental Protection Agency |
| USDA | United States Department of Agriculture |
| USFS | United States Forest Service |
| USGS | United States Geological Survey |
| VMP | Vegetation Management Plan |
| WHO | World Health Organization |
| > | greater than |
| ≥ | greater than or equal to |
| < | less than |
| ≤ | less than or equal to |
| = | equal to |
| ≅ | approximately equal to |

## Commonly Used Terms and Definitions

| | |
|---|---|
| Acid equivalent (a.e.) | For a chemical that is an ester or salt of a carboxylic acid (where carboxylic acids are organic acids characterized by the presence of a carboxyl, or -C(=O)OH), group), concentrations or weights are often given in acid equivalents, in order to express all concentrations in the consistent unit of the parent carboxylic acid, which is generally the active moiety of a compound. |
| Active ingredient (a.i.) | The individual pesticide chemical that is responsible for the pesticidal activity. Contrast the active ingredient with the acid equivalent and with the pesticide product that may contain additional ingredients. |
| Contaminated | Containing any amount of a chemical residue in a given medium. "Contaminated" does not necessarily equate to hazardous, but indicates only that the compound is present at some level. |
| Formulated product | Alternate term equivalent to pesticide product. |
| Pesticide | Any insecticide, herbicide, fungicide, rodenticide, avicide (bird killing), acaricide (mite killing), microbiocide or other compound designed to kill or deter pests. |
| Pesticide product | The mixture of ingredients sold in the marketplace that contains the active ingredient and other ingredients such as surfactants, solvents, preservatives, etc. Products are often referred to as "formulated products" to clarify the distinction between active ingredients and products. |
| Surfactant | A chemical compound added to a pesticide that acts as an emulsifier, enhances absorption and effectiveness of the pesticide, and/or changes the surface tension of a solution as a control for spray drift. |
| Understory | For Mount Sutro, understory refers to "Himalayan blackberry, other non-native and native shrubs and vines, many of which grow on tree trunks," including poison oak[1] |

[1] UCSF. 2010. Notice of Preparation/Initial Study for UCSF Mount Sutro Management, p. 5.

# Chapter 1 — Overview and Executive Summary

# 1 Table of Contents — Overview and Executive Summary

**ACRONYMS, ABBREVIATIONS AND SYMBOLS ..... I**

**COMMONLY USED TERMS AND DEFINITIONS ..... IV**

**TABLE OF TABLES ..... 1-2**

**PURPOSE OF THE REPORT ..... 1-3**

**1.1 SUMMARY OF CONCLUSIONS ..... 1-3**

1.1.1 OVERVIEW ..... 1-4

1.1.2 RISKS TO WORKERS ..... 1-5

1.1.3 RISKS TO THE GENERAL PUBLIC ..... 1-6

1.1.4 RISKS TO TERRESTRIAL WILDLIFE ..... 1-8

1.1.5 RISKS TO AQUATIC WILDLIFE ON MOUNT SUTRO ..... 1-9

1.1.6 RISKS TO AQUATIC WILDLIFE IN SAN FRANCISCO BAY AND THE PACIFIC OCEAN ..... 1-11

1.1.7 CAVEATS ..... 1-11

**1.2 REPORT OVERVIEW ..... 1-11**

**1.3 HERBICIDES, ADJUVANTS AND APPLICATION METHODS UNDER CONSIDERATION ..... 1-12**

1.3.1 HERBICIDES ..... 1-12

1.3.2 SURFACTANT ..... 1-12

1.3.3 MARKER DYE AND COLORANT ..... 1-13

1.3.4 APPLICATION METHODS ..... 1-13

**1.4 ASSESSING THE FATE OF CHEMICALS IN THE ENVIRONMENT ..... 1-13**

**1.5 THE RISK ASSESSMENT PROCESS ..... 1-15**

1.5.1 HAZARD ASSESSMENT ..... 1-15

1.5.2 EXPOSURE ASSESSMENT ..... 1-16

1.5.3 RISK CHARACTERIZATION ..... 1-17

**1.6 RISK ASSESSMENT RESULTS ..... 1-18**

# Table of Tables

Table 1-1: Comparison of RfDs and TRVs for Glyphosate and Triclopyr ..... 1-19

Table 1-2: Humans—Comparison of Herbicide Risks for Selected Exposure Scenarios ..... 1-22

Table 1-3: Terrestrial Wildlife—Comparison of Herbicide Risks for Selected Exposure Scenarios ..... 1-24

Table 1-4: Aquatic Wildlife—Comparison of Herbicide Risks for Selected Exposure Scenarios ..... 1-26

## Purpose of the Report

This report provides an assessment of the potential effects of two herbicides and two adjuvants on water quality, human health, and wildlife viability within and around the Mount Sutro Open Space Reserve adjacent to the University of California San Francisco (UCSF) Medical Center, Parnassus Campus in San Francisco. The report contains information that will enable the nearby community and UCSF to make an informed decision as to the risks associated with using these chemicals on a portion or all of the Reserve. The risks of exposing humans and other organisms to various herbicides and additives are estimated in the context of a set of mandatory restrictions on the methods for applying and transporting herbicides that minimize the probability of accidents and adverse effects.

The risk assessment provides information on the inherent hazards of the chemicals, possible routes of exposure for humans and wildlife, an estimated magnitude of exposure, and the likelihood of adverse effects and consequent risk associated with exposure.

### *1.1 Summary of Conclusions*

Two herbicides were evaluated for potential use in the Mount Sutro vegetation control project: Aquamaster® (active ingredient is glyphosate) and Garlon 4 Ultra® (active ingredient is triclopyr butoxyethyl ester). Aquamaster is proposed for both foliar and cut-stump treatments and Garlon 4 Ultra is proposed only for cut-stump treatments. Two adjuvants were also evaluated: a surfactant (Competitor) and a dye (Blazon).

Pesticide Research Institute (PRI) conducted the risk assessment for four treatment scenarios for consideration by UCSF in project planning. These scenarios bracket the range of risks for the treatment schedule outlined in Table 2-8 of Chapter 2, and assume that 14–15 acres of the 62.7-acre reserve are too steep and inaccessible to be treated.

1) **Maximum treatment scenario:** All accessible acres (48 total) treated at the maximum application rate of 4 lbs a.e./acre;
2) **Half-treatment scenario:** Half the accessible acres (24) treated at the maximum application rate or all of the acres treated at 2 lbs a.e./acre; and
3) **Quarter-treatment scenario:** One-quarter (12) of the accessible acres treated at the maximum application rate or all of the acres treated at 1 lb a.e./acre.
4) **Demonstration project scenario:** Treatment of Demonstration Project areas #1 (one acre) and #4 (two acres) at the maximum application rate of 4 lbs a.e./acre.

In many cases, Hazard Quotients (HQs)[2] are calculated on a per-acre or per-event basis. These per-acre hazard quotients typically do not differ when comparing the Main Project to the Demonstration Project, with limited exceptions discussed individually below.

[2] An exposure of concern is defined as an estimated dose that exceeds the Reference Dose (RfD) for humans or the Toxicity Reference Value (TRV) for terrestrial and aquatic wildlife. The term Hazard Quotient (HQ) is used to quantify the ratio of estimated dose to RfD or TRV, where an HQ ≥ 1 exceeds the level of concern. Scenarios with HQs between 0.1 and 1 indicate that there may be particularly sensitive individuals or species that may be affected, and are described here as exposures approaching levels of concern. See Section 1.5.3 below.

The chapters that follow provide the detailed analysis of the risks associated with use of the two herbicides Aquamaster and Garlon 4 Ultra. Overall, our analysis indicates that the project as proposed poses some risks of concern for likely exposures for workers, the general public and aquatic and terrestrial wildlife, primarily from use of triclopyr. The risks associated with glyphosate use are substantially less.

### 1.1.1 Overview

Summary tables at the end of this chapter present most likely ("Central") estimated risks for a selection of key scenarios for herbicide applicators and the general public (Table 1-2), for terrestrial wildlife (Table 1-3) and for aquatic wildlife (Table 1-4). These and additional scenarios are evaluated in Chapters 3 and 4 using not only Central assumptions, but best-case ("Lower") and worst-case ("Upper") assumptions as well. For cut-stump treatment scenarios, the Central exposure estimate is based on the herbicide products diluted to 20% product by volume. For foliar treatment solutions, the Central exposure estimate is based on the herbicide products diluted to 2% product by volume.

The highest exposures of concern (highest Hazard Quotients) for the general public were found to arise from the highly improbable scenarios of humans drinking water from puddles, pools or Woodland Creek on Mount Sutro after a spill of either Aquamaster or Garlon 4 Ultra. For workers, exposures of concern could occur from accidental spills of triclopyr (Garlon 4 Ultra) solutions onto skin, a scenario considered to be probable based on studies of workers applying pesticides. These risks are higher for women applicators using Garlon 4 Ultra, because triclopyr is more toxic to women of childbearing age.[3] For glyphosate (Aquamaster), the risks of similar worker exposure scenarios are below a level of concern. Triclopyr poses higher risks to humans from dermal exposure than glyphosate because of its greater dermal permeability and higher toxicity to women of childbearing age.

For terrestrial wildlife, the exposures that exceed a dose of concern involve drinking contaminated water from puddles, pools or Woodland Creek after herbicide spills, for both glyphosate and triclopyr. These exposures are considered improbable, because the likelihood of spills is low if the guidelines are followed.

For aquatic wildlife, amphibians that use seasonal pools and puddles for breeding habitat are most at risk from herbicide spills and overland flow for both glyphosate and triclopyr, and from herbicide runoff into Woodland Creek if all acres in the Woodland Creek watershed are treated (triclopyr only). Triclopyr poses higher risks to aquatic life than glyphosate because of its higher toxicity. Concentrations of glyphosate and triclopyr in runoff that reaches the San Francisco Bay and the Pacific Ocean are very low and do not pose a hazard to aquatic life. It was not possible to quantitatively estimate exposures from the contamination of puddles or small pools from overland flow; however, this exposure scenario is probable and has the potential to disrupt amphibian breeding in heavily treated areas.

The risk profiles for the Maximum treatment scenario and the Demonstration Projects treatment scenario are the same for most of the high-risk exposures described above for workers, the

[3] Triclopyr has been observed to cause birth defects in laboratory animals, thus the fetus is at risk. See Chapter 4, Section 4.3.1 for a discussion of the animal studies.

general public and terrestrial and aquatic wildlife because they are calculated on a per-event basis. The risks differ between the Maximum and Demonstration Project treatment scenarios in the case of water contamination caused by runoff from treated areas and general worker exposure. Estimated exposures are below levels of concern for all but the Upper (worst-case) exposure estimate from the Maximum treatment scenario for amphibians and aquatic invertebrates exposed to triclopyr runoff.

UCSF has developed a set of guidelines for the Mount Sutro forest vegetation management plan, presented in detail in Section 2.5.1.A in Chapter 2, and the risk assessment was conducted assuming compliance with the guidelines. It is possible to further reduce the risks for the more likely exposure scenarios by:

- Minimizing the use of triclopyr-based herbicides to reduce risks to workers, the general public, and wildlife. Glyphosate-based herbicides appear to be equally effective in cut-stump treatments if stumps are treated immediately after cutting. This approach is particularly recommended for the watershed that borders on the Interior Greenbelt, since this is the only watershed that could produce runoff that enters private property.
- Using the lowest concentrations of herbicide possible for cut-stump treatments. Efficacy studies indicate that concentrations of glyphosate and triclopyr products as low as five percent can be as effective as 50–100 percent solutions if stumps are treated immediately after cutting (see Chapter 2 for a discussion of these studies). Use of a more dilute herbicide solution will also allow for treatment of more trees per acre, thereby avoiding limitations in the number of trees that can be treated.
- Cutting vegetation prior to treatment to minimize the potential for direct sprays to wildlife and contact with treated vegetation for workers, the general public, and terrestrial wildlife.
- Applying herbicides as early as possible in the summer to allow time for degradation to occur prior to the rainy season when possible.
- Changing spill-handling procedures to require thorough cleanup of all spills to puddles and to land.
- Filling in depressions where puddles might form near heavily treated areas to reduce the probability that overland flow from treated sites would contaminate areas that could be used as amphibian breeding habitat.

These recommendations and other application guidelines are discussed in detail in Chapter 6. A summary of the risk findings for the vegetation management project on Mount Sutro follows. The summary focuses on the most likely or “Central” dose estimates, and discusses the worst-case “Upper” estimates for some scenarios where only the Upper estimate exceeds a level of concern.

### 1.1.2 Risks to Workers

Herbicide applicators can be exposed to herbicides through accidental spills or sprays that result in skin exposure and through the general exposure that occurs while working with herbicides, including brushing up against contaminated vegetation and inhaling spray mists. All of these exposures are considered to be probable. For the Mount Sutro project, the primary risks of

concern to workers are from dermal and general exposures to triclopyr. For glyphosate, none of the worker exposure scenarios exceeds a level of concern.

The highest risk was for women applicators exposed to an accidental spill of a cut-stump triclopyr solution into a glove that was left unwashed for one hour, resulting in an estimated Central dose that is 327 times the acute Reference Dose (RfD). For men, this same scenario still exceeds the RfD by 15 times. This scenario is unlikely if workers follow the guidelines of washing as soon after a spill as possible; however, even the more probable scenario of a spill left on the skin for one minute would result in a dose that is 5.5 times the acute RfD for women but only 25 percent of the RfD for men.

General worker exposures that occur from ordinary chemical handling and contact with treated surfaces and spray drift during the application approaches a level of concern for triclopyr, with doses 99 percent of the chronic RfD for the Maximum treatment scenario. For general handling exposure for workers, the chronic RfD is used for comparison because it is assumed that workers are handling herbicide on a regular basis. General exposure estimates were calculated using the assumption that a spray applicator would be used for treating cut stems/stumps; however, if only a brush or wick applicator were used, risks could be reduced substantially, by approximately a factor of 10.

The highest worker glyphosate exposure scenario was the general exposure for a worker conducting foliar sprays, with an Upper dose that is 16% of the acute RfD (note that table 1-2 presents only Central estimates). Since women are not especially sensitive to glyphosate, there is no distinction between men and women applicators. No other glyphosate worker exposure scenarios exceed an HQ of 0.1.

Because all of the accidental worker exposure estimates are on a per day or per-event basis, there is no difference in the risk profile between the Maximum treatment scenario and the Demonstration Projects. However, for the general worker exposure, there is a difference in the risk profile. For applicators using triclopyr solutions for cut-stump applications, the HQ is very close to a level of concern at 99% of the chronic RfD for the Maximum treatment scenario. This risk drops to 25% of the RfD for the Demonstration Project. None of the corresponding glyphosate scenarios approach levels of concern.

The risks for workers can be reduced by ensuring that herbicide applicators follow the Application Guidelines in Section 2.5.1.A of Chapter 2, with particular attention to rapid cleanup after spills, and for triclopyr applicators, wearing two layers of gloves and incorporating some form of physical separation between the backpack sprayer and the applicator to prevent dermal exposure from a leaking backpack sprayer.

### 1.1.3 Risks to the General Public

The general public could be exposed to herbicides by contact with treated vegetation or cut stumps, by direct sprays and by drinking contaminated water out of Woodland Creek or a contaminated puddle. Both the direct spray scenarios and the scenarios for children or adult males drinking contaminated water out of Woodland Creek or a contaminated puddle are highly improbable; however, contact with treated vegetation or cut stumps is possible.

For both foliar and cut-stump treatments using glyphosate, dermal exposures from contaminated vegetation do not exceed levels of concern for the general public for any scenario. For treatments using triclopyr, the direct spray with a cut-stump solution exceeds levels of concern for women and children. Sitting on a treated stump in shorts approaches a level of concern for women. Drinking water contaminated by spills exceeds levels of concern for both glyphosate and triclopyr. Drinking out of Woodland Creek contaminated by herbicide runoff from treated sites does not exceed levels of concern for either glyphosate or triclopyr, although the Upper HQs for triclopyr approach levels of concern. For homes that border the reserve, the probability of herbicide-contaminated runoff entering private property is very low, since most rainfall runoff from the reserve is captured by storm drains. One small watershed that borders private property will not be treated with herbicides, and another 2.5 acre watershed that drains to private property is separated from private property by the Interior Greenbelt as a buffer zone that will trap much of the herbicide runoff.

The highest risk for the general public arises from the improbable scenario of women who are directly sprayed on the feet and lower legs with cut-stump triclopyr solutions, with an estimated Central dose 2.2 times the Reference Dose (RfD); for a child sprayed over the entire body, the exposure is 1.1 times the RfD. The difference in the HQs is primarily because of the lower RfD used for women of childbearing age for triclopyr compared to the RfD used for a child. For glyphosate, the Upper estimate for the direct spray of a child's entire body was 18% of the RfD. The direct spray scenarios are unlikely if the work area is posted as required by the guidelines, and applicators are cognizant of their surroundings and stop spraying when people approach. Posting the treated area after the treatments and the use of blue dye on cut stumps in other treated areas will reduce the probability of people contacting treated vegetation.

All exposures from drinking contaminated water after an accidental spill were above levels of concern. The highest exposures are for a child drinking contaminated water from Woodland Creek after 20-gallon spill of cut-stump solution, with a Central HQ of 321 for glyphosate and 642 for triclopyr. This scenario would only occur if a truck containing 20 gallons of herbicide were to go off the road precisely where Woodland Creek crosses the road. More likely would be a smaller spill from overturning a container of herbicide. However, even the scenario of a one-gallon spill of a dilute glyphosate foliar treatment solution into Woodland Creek exceeds levels of concern, with a Central HQ of 1.6. Mitigation measures that will reduce the probability of contaminating water from accidental spills include limiting the mixing and loading of herbicide solutions to an area where spills can be contained, limiting the volume of herbicide that can be transported on-site, and transporting herbicides in a spill-proof, sealed container at all times.

Drinking contaminated water from Woodland Creek after peak runoff is a highly improbable scenario, since Woodland Creek is not a public water supply, but this scenario was considered as a worst-case scenario for children and adult females. Central exposure estimates are not of concern; even the Upper estimates for triclopyr are only 11% and 18% of the RfDs, respectively, for the Maximum treatment scenario. The Half, Quarter and Demonstration treatments are all well below a level of concern for both herbicides.

Because exposures from direct sprays, accidental spills, and contact with contaminated vegetation are on a per-event basis, there is no difference in the risk profile between the Maximum, Half and Quarter treatment scenarios and the Demonstration Projects for these scenarios.

### 1.1.4 Risks to Terrestrial Wildlife

Terrestrial wildlife can be exposed to herbicides through direct sprays, by brushing up against treated vegetation or cut stumps, by drinking contaminated water and by eating contaminated food. Direct sprays are possible for small mammals and insects, although it is unlikely that a large number will be exposed in this way because of the highly targeted nature of the proposed treatments. Exposures from ingesting contaminated food and water are more probable, especially for small mammals living on or near a treated site. Exposures for terrestrial wildlife exceed levels of concern for drinking contaminated water for both triclopyr and glyphosate and from direct sprays with triclopyr.

For the Mount Sutro project, the primary risks of concern to terrestrial animals are drinking contaminated water after a spill of glyphosate or triclopyr to a puddle or Woodland Creek, which results in estimated doses many times the Toxicity Reference Value (TRV) for mammals and birds even for Central estimates of the smaller one-gallon spills. Mitigation measures that will reduce the probability of contaminating water from accidental spills include limiting the mixing and loading of herbicide solutions to an area where spills can be contained, limiting the volume of herbicide that can be transported on-site, and transporting herbicides in a spill-proof, sealed container at all times.

Secondary concerns are direct sprays for small mammals and insects, and eating contaminated vegetation or fruit. The estimated Central dose for a direct spray of a small mammal with triclopyr is 79 percent of the TRV for first-order absorption; for glyphosate, this same direct spray scenario resulted in a dose estimate that is 0.19 percent of the TRV. Central exposure estimates for consumption of contaminated food did not exceed the TRVs for either triclopyr or glyphosate; the highest Central exposure estimate produces an HQ of 0.36 for a small bird eating insects contaminated with triclopyr.

The most probable exposure scenarios for terrestrial wildlife involve drinking contaminated water after herbicide runoff from treated sites into Woodland Creek, puddles or pools. Contaminated runoff in Woodland Creek would be diluted quickly, to the point that even worst-case estimates are well below levels of concern for all terrestrial wildlife modeled; however, concerns remain about pools or puddles contaminated by herbicide runoff from treated sites. We were unable to quantitatively estimate herbicide concentrations for this scenario because insufficient data were available, but based on US Geological Survey studies of herbicide occurrence in water bodies near treated sites and in overland flow, and several other studies demonstrating high concentrations of herbicides in soils near cut-stump treatment sites, we conclude that it is possible that small-volume puddles and pools that may be used as drinking water sources for small mammals and birds could contain high concentrations of herbicides from runoff. The amount of herbicide in puddles could be minimized by using the lowest effective concentration of herbicide for cut-stump treatments (5% solutions), by filling in ruts or depressions near treatment sites, and by requiring applicator teams to clean up any spills to land

immediately by adding absorbent material to the spill site and disposing of this material appropriately.

Because exposures from direct sprays, accidental spills, and contact with contaminated vegetation are on a per-event basis, there is no difference in the risk profile between the Maximum, Half, and Quarter treatment scenarios and the Demonstration Projects. For consumption of contaminated food and water from puddles or pools, there may be no difference in risk between the Maximum treatment scenario and the Demonstration plots for individual animals living in a treated area if they eat and drink primarily from the treated area; however, population-level impacts will be lower if only the two-acre Demonstration plot is treated.

### 1.1.5 Risks to Aquatic Wildlife on Mount Sutro

Aquatic wildlife, including amphibians, aquatic invertebrates, and algae can be exposed to herbicides through spills of herbicide into Woodland Creek, puddles or pools on the Mount Sutro, as well as by herbicide runoff from treated sites. While the spill scenarios are unlikely, herbicide runoff is likely to occur if herbicide applications are conducted within a few months of the rainy season. Amphibians and aquatic invertebrates that breed in seasonal pools or puddles are especially at risk from both glyphosate and triclopyr, with triclopyr having higher toxicity to aquatic life.

The risk analysis for triclopyr is more complex for aquatic organisms because of the variation in toxicity between the different forms of triclopyr and the time frame of triclopyr BEE degradation relative to potential exposures. Triclopyr BEE (the active ingredient in Garlon 4 Ultra) degrades fairly rapidly in the environment (a half-life of a few days to a few weeks) to triclopyr acid, which then degrades over a longer time frame (a half-life of a few weeks to a few months) to 3,5,6-trichloro-2-pyridinol (TCP). Aerobic degradation of triclopyr in soil produces the metabolites TCP, $CO_2$, and 3,5,6-trichloro-2-methoxypyridine (TMP). In the analysis of risks to aquatic species, we provide hazard quotients (HQs) for triclopyr BEE, triclopyr acid and TCP. Toxicity Reference Values (TRVs) for triclopyr BEE are used for determining HQs for acute scenarios such as spills, since this is the active ingredient under consideration for use in Mount Sutro watersheds, and no degradation will have yet occurred at the time of a spill.

The HQs for exposures to all three compounds are provided for evaluating exposures from peak and long-term runoff. A peak runoff event that occurs within a few days of application of Garlon IV Ultra will result in exposure primarily to triclopyr BEE, since little degradation will have taken place. As time progresses, degradation of the applied BEE compound will occur to form triclopyr acid and then TCP. For long-term runoff where aquatic organisms may be exposed over several months, the primary compounds of concern will be triclopyr acid and TCP, since triclopyr BEE will have degraded to the acid within a few days. For either peak runoff or long-term runoff, organisms will likely be exposed to a mixture of these compounds. It is impossible to determine the precise mixture of compounds that might be present at a given time, but taking action to mitigate the worst-case scenario will ensure protection of species.

The primary risks of concern for aquatic wildlife are glyphosate or triclopyr spills to a puddle or Woodland Creek, which results in estimated doses from three to hundreds of thousands times the TRV for amphibians, aquatic invertebrates, and algae, even for Central estimates of the smaller

one-gallon spills. Mitigation measures that will reduce the probability of contaminating water from accidental spills include limiting the mixing and loading of herbicide solutions to an area where spills can be contained, limiting the volume of herbicide that can be transported on-site, and transporting herbicides in a spill-proof, sealed container at all times.

For herbicide runoff into Woodland Creek, Central estimates for aquatic organisms exposed to triclopyr are below levels of concern for amphibians and aquatic invertebrates, but exceed levels of concern for aquatic plants, with an HQ 1.1 times the TRV for peak runoff of triclopyr BEE with the Maximum treatment scenario. No estimates exceeded levels of concern for glyphosate. For amphibians, only the Upper estimates of triclopyr BEE exposures exceed levels of concern, with an HQ of 1.2 for the Upper estimate.

Contaminated runoff to Woodland Creek exceeds levels of concern for aquatic organisms, but not by a large margin; however, concerns remain about pools or puddles contaminated by herbicide runoff from treated sites. We were unable to quantitatively estimate herbicide concentrations for this scenario because insufficient data were available, but based on US Geological Survey studies of herbicide occurrence in water bodies near treated sites and in overland flow, and several other studies demonstrating high concentrations of herbicides in soils near cut-stump treatment sites, we conclude that it is possible that small-volume puddles and pools that may be used as drinking water sources for small mammals and birds could contain high concentrations of herbicides from runoff. The amount of herbicide in puddles could be minimized by using the lowest effective concentration of herbicide for cut-stump treatments (5% solutions), by filling in ruts or depressions near treatment sites, and by requiring applicator teams to clean up any spills to land immediately by adding absorbent material to the spill site and disposing of this material appropriately. Risks to aquatic species that use puddles for breeding habitat could be further reduced by filling in ruts or depressions near treatment sites and by requiring applicator teams to clean up any spills to land immediately by adding absorbent material to the spill site and disposing of this material appropriately.

Because exposures from accidental spills are on a per-event basis, there is no difference in the risk profile between the Maximum, Half, and Quarter treatment scenarios and the Demonstration Projects. For exposure to contaminated water in puddles or pools, there may be no difference in risk between the Maximum treatment scenario and the Demonstration plots for individual animals living in a contaminated puddle or pool; however, fewer pools will be contaminated and population-level impacts will be lower if only the two-acre Demonstration plot is treated. For aquatic organisms living in Woodland Creek, there will be substantial differences in the amount of herbicide runoff into Woodland Creek between the Maximum, Half, and Quarter treatment scenario and the Demonstration plots that is directly proportional to the area treated. One mitigating factor is that Woodland Creek only drains a small part of the Mount Sutro reserve (9 acres, of which only 7 would be treated because of inaccessibility), so the runoff would be limited. Runoff from the other watersheds on Mount Sutro will be intercepted by the storm drains that will direct the flow to the wastewater treatment plants, where the runoff is further diluted by inflows from the rest of San Francisco and finally by the receiving water in the San Francisco Bay and the Pacific Ocean.

### 1.1.6 Risks to Aquatic Wildlife in San Francisco Bay and the Pacific Ocean

The concentrations of herbicides in runoff from Mount Sutro were estimated at both the Southeast and Oceanside wastewater treatment plants (WWTP) for peak runoff occurring during the 5-year storm event for the four treatment scenarios described in Section 1.1 above (Maximum, Half, Quarter and Demonstration Projects) and risks were estimated for fish, aquatic invertebrates, and aquatic plants in the San Francisco Bay and the Pacific Ocean near the WWTP outfalls. Estimated concentrations of glyphosate and triclopyr in runoff that reaches the San Francisco Bay and the Pacific Ocean were found to be very low and would not pose a hazard to aquatic life.

### 1.1.7 Caveats

The herbicides and additives being considered are all materials that are potentially toxic to humans and other life. They can all cause adverse effects if people or other organisms are exposed to hazardous amounts of the materials for a sufficient period of time. There is no such thing as a "safe" herbicide; all herbicides have the potential to cause adverse health effects at some level of exposure.

There are many data gaps and uncertainties involved in assessing the risk of these chemicals, and it should be recognized that the conclusions drawn in the risk assessment are only as good as the available toxicity studies. This report contains a full and detailed accounting of the uncertainties and data gaps. Specifically, there are uncertainties in estimating the amount of herbicide that may run off from the treatment sites and the toxicity of these herbicides to humans and wildlife at very low doses, especially endocrine disrupting effects. In addition, less is known about triclopyr as compared to glyphosate, and there is very little information about the surfactants or the dye. No information is available on the toxicity of mixtures of the two herbicides. This report uses a precautionary approach to account for uncertainty in exposure estimates, providing worst-case exposure estimates for consideration, as well as lowest and most likely exposure estimates.

## *1.2 Report Overview*

Following this Introduction and Summary chapter, Chapter 2 provides the essential background information necessary for interpreting the risk assessment. Chapter 2 is divided into the following sections:

- Human health impacts of chemical exposure
- Effects of chemical exposure on animals and other organisms
- Pathways by which chemicals are transported and degrade in the environment
- Development of application guidelines to minimize risks and assessment of exposure pathways and anticipated exposures
- Risk characterization, comparing plausible levels of exposure with levels of concern
- An assessment of the US Forest Service (USFS) approach to estimating risks from herbicide treatments

Chapters 3 through 5 provide a summary of available information on the above-mentioned topics for each active ingredient and adjuvant, as well as information about the specific products

selected for potential use for this project. Chapter 6 provides recommendations for minimizing herbicide use and mitigating potential adverse effects.

The summary of human health and ecological impacts presented in this document are not, and are not intended to be, comprehensive summaries of all of the available information, and these risk assessments do not cite all of the available literature. However, the studies most relevant to the Mount Sutro project are discussed in detail.

## *1.3 Herbicides, Adjuvants and Application Methods Under Consideration*

This document focuses on the information necessary to assess the risks of use of a few specific herbicide products in the Mount Sutro Reserve. Two herbicides, one surfactant and one dye were selected for the risk assessment. These chemicals are described below.

### 1.3.1 Herbicides

Herbicides would be spot applied by a wick, sponge, squirt bottle or directed-spray applicator to cut stems or, for certain species such as Ehrharta, to foliage. UCSF has made a commitment to not conduct broadcast or widespread vegetation spraying.

***Aquamaster***® (active ingredient: glyphosate) is formulated as a four pounds a.i./gallon of the isopropyl amine salt. Water is the only "inert" ingredient; no surfactant is included in the Aquamaster formulation. Aquamaster is a broad-spectrum, non-selective, systemic, post-emergent herbicide used to control annual and perennial plants, including grasses, sedges, broad-leaved weeds, and woody plants. It has no pre-emergent activity. Aquamaster would be prescribed primarily for understory vegetation such as Himalayan blackberry, other non-native and native shrubs and vines, and poison oak and applied as a 1–5 percent solution for low-volume, spot treatment delivery. Aquamaster could also be applied to freshly cut stumps/stems of trees and woody plants at concentrations of 5-50 percent. In either case, application rates would be limited to four pounds of formulated product per acre.

***Garlon 4 Ultra***® (active ingredient: triclopyr butoxyethyl ester) is a broadleaf selective, post-emergent, terrestrial herbicide used for control of most annual and perennial broadleaf weeds and brush in crop and non-crop sites. Garlon 4 Ultra is an auxin-mimicking herbicide, specifically, the auxin indole-3-acetic acid (IAA), a plant hormone that regulates cell division and expansion. It is transported through the phloem and xylem of the plant and accumulates in the meristematic tissue of the shoots of susceptible plants, accelerating growth and resulting in ruptured cell walls. Triclopyr is rapidly metabolized in the plant with 85 percent of a dose being metabolized within three days. Garlon 4 Ultra would be prescribed for application to cut stumps of eucalyptus, acacia, and holly trees to help prevent regrowth, but would not be used as a foliar treatment. A 5–50 percent solution of Garlon 4 Ultra would be applied as a cut-stump treatment. Application rates would be limited to four pounds of formulated product per acre.

### 1.3.2 Surfactant

Surface-active agents, or surfactants, are additives used to enhance the activity of foliar applied herbicides. Many commercial herbicide formulations already contain internal surfactants. While the label might not require adding a surfactant, the addition of one will generally improve herbicidal activity. Herbicides formulated without surfactants have little to no activity without

the addition of a surfactant. There are several classes of surfactant. If herbicides are included in the final vegetation management plan, the surfactant would be utilized for both foliar and cut-stump applications.

***Competitor*** is in a class of surfactants known as modified seed oils (MSOs), comprised of a mixture of ethyl oleate, sorbitan alkylpolyethoxylate, and dialkyl polyoxyethylene glycol (PEG). Competitor reduces the surface tension of water on the surface of the leaf, breaks down the waxy surface of the leaf, and aids in moisture retention on the leaf surface. These combined characteristics work to enhance the uptake of the herbicide. Competitor would be used as a surfactant in low-volume foliar applications and as a diluent for basal and cut stump applications at concentrations of 1–3 percent. As a diluent, Competitor would comprise 50–95 percent of a mixture with Garlon 4 Ultra for basal and cut-stump treatments.

### 1.3.3 Marker Dye and Colorant

Dyes are used to show where an herbicide application has been made to avoid retreatment and ensure that all target plants are treated. They are beneficial, as they help prevent skips, overlap and incidental exposure during reentry. They also help determine potential off-target injury. One marker dye—Blazon blue dye—is proposed for possible use in the Mount Sutro vegetation management project for use with all foliar applications and with some cut stump applications.

### 1.3.4 Application Methods

For cut-stump treatments, herbicide product labels typically recommend using a 50–100 percent solution of a highly concentrated formulated product. However, using highly concentrated solutions of herbicide amplifies the potential for adverse effects to workers, the general public and wildlife from accidental spills, general handling exposure, and imprecise applications that result in contamination of adjacent areas and higher runoff to water bodies. The amount of contamination of the adjacent area is affected primarily by three variables: 1) the concentration of the herbicide solution used, 2) the precision of the method of application, and 3) the amount of herbicide applied per cut stump. As discussed in Chapter 2, research on the efficacy of different concentrations of herbicide indicate that treatments can be effective with solutions as dilute as five percent.

## *1.4 Assessing the Fate of Chemicals in the Environment*

Once released into the environment, herbicides, surfactants and dyes are subject to a number of processes that transport them away from the application site or degrade them into smaller molecules. Specifically, these chemicals are transported off-site by water and air and degraded or inactivated by microbial and chemical reactions. Understanding these processes is critical for the assessment of questions of actual risk of exposure, such as 1) Are Woodland Creek, puddles or pools, San Francisco Bay or the Pacific Ocean likely to be contaminated by herbicide use? 2) Are recreational users likely to be exposed to herbicides by spending time near an application site? and 3) Will wildlife be exposed to herbicides from eating contaminated vegetation?

Herbicides can be transported away from the site where they were applied by water, air and soil movement. They can also be degraded by chemical or biological processes. Water transports herbicides off-site by leaching of dissolved herbicides through soil to groundwater, surface runoff of dissolved herbicides, and by surface runoff of soil-bound herbicides.

- **Leaching to groundwater:** Herbicides can dissolve in water and percolate through the soil, sometimes traveling as far as the water table. Herbicides most prone to this process have high water solubility, low ability to adsorb to soils, and long half-lives. Even herbicides that do not have these characteristics may still contaminate groundwater by traveling through rocky or fractured soils that provide a direct pathway to groundwater. High pesticide application rates and heavy rains will enhance transport to groundwater. Once in groundwater, herbicides are not exposed to sunlight and microbes, and typically degrade much more slowly than in soils or surface waters.

- **Surface runoff of dissolved and adsorbed herbicides:** During heavy rains or high irrigation flows, herbicides can be dissolved and transported in runoff water. If the runoff event has sufficient volume and energy to carry sediment particles, even herbicides that are not particularly water-soluble can still be transported in the flow adsorbed to sediment and deposited in a new location.

Herbicides may also be transported off-site through the air, by spray drift during the application and/or volatilization drift that occurs both during and after the application.

- **Spray drift:** Spray drift occurs during and for a few hours after a pesticide spray application, as fine droplets or dust particles created by spray equipment are carried off-site by prevailing winds. Spray drift of herbicides can affect non-target plants, animals, and humans near an application site at the time of the application. Both dermal and inhalation exposure are possible.

- **Volatilization drift:** Volatilization drift occurs primarily with herbicides with moderate to high vapor pressures. Higher vapor pressure and temperature lead to greater volatilization and subsequent wind transport. None of the herbicides reviewed in this risk assessment have high vapor pressures, indicating that volatilization drift is not a significant source of herbicide transport for these herbicides.

- **Wind erosion:** Transport of herbicides on dust particles can occur through wind erosion of dry and exposed soils. Deposition of herbicide-contaminated soils can damage non-target plants and contaminate waterways far from the original application site.

Most herbicides are degraded in the environment by microbial activity, photolysis, hydrolysis and other chemical reactions.

- **Microbial activity:** Soil microbes—bacteria and fungi—metabolize most chemicals, using them as a source of organic carbon. Some microbes have been observed to adapt to applications of herbicides by increasing the rate at which they metabolize that particular chemical.

- **Photolysis:** Sunlight, particularly in combination with oxygen in the air, can break chemical bonds and degrade herbicides in air, water and soil.

- **Hydrolysis and other chemical reactions:** Herbicides can also be degraded through reaction with water (hydrolysis) or other substances in the environment. Some chemical reactions do not necessarily degrade the chemical structure, but may result in the formation of a new molecule or complex that changes the reactivity of the parent pesticide. An example of this is the complexation of glyphosate to clay soils, which decreases the bioavailability and the toxicity of this herbicide.

## *1.5 The Risk Assessment Process*

Risk assessment is defined as the qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants. ***Risk*** is a measure of the probability that damage to life, health, and/or the environment will occur as a result of a given hazard. The assessment of risk requires knowledge of the inherent toxicity of chemical being assessed (the ***hazard***), the amount and time of ***exposure***, and the ***probability*** of that exposure occurring.

### 1.5.1 Hazard Assessment

The ***hazard*** data described in this report provide information on the types of adverse effects that the herbicide may cause at the various doses (i.e., how much exposure per unit of body weight) evaluated in animal tests. Acute effects are short-term effects that occur close in time to the exposure—within a few minutes to 24 hours. Chronic effects such as cancer or sterility typically occur after longer exposure times, a few weeks to a lifetime. Local (topical) effects are those that affect only the surfaces contacted that come in contact with the pesticide, such as the eyes, skin, nose and throat. Systemic poisoning occurs when a toxic chemical enters the blood stream and is carried throughout the body, adversely affecting internal organs and body systems.

There are uncertainties in hazard assessment, including translation of results in laboratory animals to humans; failure of study designs to adequately measure all toxic effects, especially in developing organisms; misinterpretation of study results; and failure to assess the effects of exposure to multiple chemicals that may be present in a product. These uncertainties are discussed in detail in Section 2.5.7.A.

The U.S. Environmental Protection Agency (EPA) classifies herbicides into four categories based on ***acute health effects*** (toxicity) in animals: Toxicity Class I (called Tox I) are the most toxic, Tox II are moderately toxic, Tox III are of low acute toxicity and Tox IV are the least acutely toxic. The EPA also estimates a lowest ***no observable adverse effect level (NOAEL)***; this is the dose below which no adverse health effects are anticipated. The daily dose that is not anticipated to cause non-cancer adverse effects is known as the ***reference dose (RfD)***. Reference doses are given for oral, dermal and inhalation exposures, and for acute, subchronic, and chronic time periods of exposure.

***Chronic health effects*** are long-term effects that include cancer, reproductive problems, impaired development and neurological disease, among others. The EPA assesses the risk of human chronic health effects of herbicides based on animal data submitted by the pesticide manufacturer to register a product. There are no human dosing studies available for most herbicides, so the anticipated effects on humans are determined based on animal studies and human epidemiological studies that evaluate the links between exposure and incidence of

disease. Cancer cases related to pesticide exposure typically develop years after exposure and can result from legal use of herbicides that does not cause any apparent acute illness. It is difficult for an epidemiological study to single out a particular pesticide as the cause of a specific cancer, because those who are exposed to the pesticide of interest are typically also exposed to other pesticides, and use patterns of these pesticides have changed over time. In addition, pesticides might act synergistically, and cumulative exposures over time are difficult to document. If the type of cancer is rare or infrequent, or the number of people in an exposed group is small, an association with pesticide exposure may not be found, even if one exists.

Chemically induced endocrine disruption is a new area of research, and current toxicology tests do not evaluate endocrine disrupting potential. The endocrine system is composed of glands that secrete hormones directly into the blood system, including the ovaries and testes, the thyroid, parathyroid, adrenals, pituitary, and pancreas. Small changes in hormone levels are known to affect reproduction, neurological development, sexual development, metabolic processes, and mood, and may have other effects. Hormones play a crucial role in guiding normal cell differentiation in early life forms, and exposure to endocrine disrupting substances in the egg or in the womb can alter the normal process of development. Mature animals can also be affected, but it is the developing organism that is especially vulnerable. Exposure at this time may cause effects that are not evident until later in life, such as adverse effects on learning ability, behavior, reproduction and increased susceptibility to cancer and other diseases. The toxicologists' mantra of "The dose makes the poison" does not necessarily hold true in the domain of endocrine effects. Endocrine-disrupting substances have effects at very low, potentially environmentally relevant, doses far below those used in typical toxicology studies. These effects often disappear at higher doses that may trigger an organism's chemical detoxification mechanisms and/or inhibition pathways. Unfortunately, to date little testing has been done specifically for endocrine disrupting effects. In the fall of 2009, US EPA initiated its endocrine disruptor screening program for approximately 70 pesticide active ingredients. Results will not be available for several years.

There is no evidence suggesting that any of the pesticide active ingredients, identified "inert" ingredients, or surfactants being considered for use within the Mount Sutro Reserve are endocrine disruptors at low doses in humans or animals. However, some of the pesticide products contain unidentified "inert" ingredients for which no information is available. In addition, no definitive testing has been done to confirm the endocrine-disrupting status of any of the pesticide active ingredients, surfactants, or mixtures of these ingredients.

### 1.5.2 Exposure Assessment

***Exposure assessment*** involves estimation of exposures through all available routes, including drinking water, skin (dermal) contact, inhalation, and ingestion of contaminated food sources. A number of computer models have been developed to facilitate this type of analysis. The exposure analysis is divided into four broad categories: workers, the general public, terrestrial animals, and aquatic organisms. Hazard quotients above one suggest that a species or taxa group is likely to encounter environmental concentrations/doses that are likely to pose a risk to individuals of a species.

Water contamination estimates were developed for several acute spill scenarios, peak runoff, and long-term runoff that might result in exposure through drinking water. These concentration estimates were used to estimate exposures from consuming contaminated water for humans, terrestrial and aquatic animals, and aquatic plants. Aquatic exposure scenarios included both short-term accidental and long-term runoff from treated sites (in milligrams [mg] of the chemical per liter of water per pound applied per acre).

Human exposure estimates were developed for both workers and the general public. Worker exposure estimates considered both everyday and accidental exposures, where exposure rates are expressed in units of mg of absorbed dose per kilogram of body weight per pound of chemical handled. The exposure assumptions were derived using proposed application rates, the physical properties of the herbicides, and observational exposure data for workers mixing, loading, or applying herbicides.

### 1.5.3 Risk Characterization

***Risk*** is a measure of the probability that adverse effects will occur given a particular exposure scenario for a particular chemical. High toxicity alone does not necessarily equal high risk. If there are few routes of exposure or if organisms are only exposed to very small quantities of the chemical, risk would be anticipated to be low. Exceptions to this “dose-makes-the-poison” paradigm are the low-dose effects observed from exposures to endocrine-disrupting chemicals. Endocrine disruption may occur at doses below those known to cause the toxicity that is typically evaluated with standard high-dose animal studies. Endocrine-disrupting chemicals may be more toxic at very low doses than at low to moderate doses. Although some information is available in the peer-reviewed literature, EPA is only now beginning a large-scale endocrine disruptor screening program with validated assays.

To evaluate risk, ***exposure estimates*** are compared to a standardized reference value defined as the ***toxicity reference value (TRV)*** to obtain a ***hazard quotient*** (which is the ratio of the estimated exposure to the TRV). For humans, the TRV is defined as being the equivalent to US EPA’s "***reference dose***" (**RfD)** (i.e., the level of exposure below which no adverse effects are anticipated). Thus, if the exposure has the potential to cause a known adverse health effect, then the hazard quotient would be greater than 1.0. Hazard quotients above one indicate that exposure exceeds the level of concern, and humans or wildlife may be at risk of adverse effects. These scenarios are flagged as potentially problematic and recommendations are made for avoiding them. Hazard quotients between 0.1 and 1.0 suggest that there may be particularly sensitive individuals or species that may be affected. Hazard quotients below 0.1 indicate low levels of risk for the effects that have been studied and are represented by the TRVs. In this report, hazard quotients (HQs) less than one are reported as a percent of the TRV; HQs greater than one are reported as a multiple of the TRV, e.g. “the HQ was 2.4 times the TRV," or it was 2.4 times greater than the level below which no adverse effects are anticipated.

Risk assessments can only be conducted for chemicals for which toxicity data and physical properties are available. For the Mount Sutro project, sufficient data were not available to conduct a risk assessment for the surfactant Competitor and the dye Blazon.

## 1.6 Risk Assessment Results

When considering the potential impacts of herbicide use in the Mount Sutro Reserve, five basic questions were evaluated, specifically:

***What are the levels of concern for each herbicide for humans and wildlife?*** Based on published toxicological reports, the report identifies what levels of exposure are known to be harmful to humans and other species as well as what exposure thresholds are below the level where no adverse effects are anticipated. Epidemiological studies (where available) are used to provide a population-based view of the links between herbicide exposures and disease in humans. This report summarizes the available studies as well as highlighting data gaps (i.e., risks and hazards that have not been sufficiently studied to conclusively summarize impacts).

Table 1-1 provides the reference doses (RfDs) and toxicity reference values (TRVs) used in the analysis for the different herbicides. For example, the reference dose for glyphosate is 2 milligrams of glyphosate per kilogram (mg/kg) of body weight per day. This means that no adverse effects would be anticipated if a person were exposed to a dose of glyphosate up to 2 mg/kg per day. Lower values of RfDs or TRVs mean that the chemical is more toxic, and adverse effects occur at lower doses. For plants, TRVs are expressed as an application rate in pounds per acre at which vegetative growth (vegetative vigor) or seed emergence is not inhibited. For aquatic species, TRVs are expressed as concentrations in water in milligrams per liter (mg/L), below which no adverse effects are anticipated. For some herbicides, certain aquatic species are particularly sensitive and others particularly tolerant to chemical exposures, and different TRVs are used for these two groups.

The RfDs and TRVs in Table 1-1 are given for both acute and chronic exposure times, with the acute RfDs for exposures lasting a few hours to 24 hours and the chronic RfDs representing exposure over a longer time period—a few months to a lifetime. Chronic RfDs are generally lower than acute RfDs because an organism is more vulnerable to adverse effects if exposure continues over a longer period of time. Chapters 3 and 4 provide detailed analyses of the studies on which these reference values are based.

In general, triclopyr has lower human RfDs and mammalian TRVs (i.e., less exposure is needed to cause adverse health effects) than glyphosate, suggesting that it is inherently more toxic to mammals. Triclopyr is particularly toxic to pregnant animals, causing severe birth defects in the fetus if the mother is exposed during pregnancy. As a result, the acute triclopyr RfD for women of childbearing age is 20 times lower than the RfD for men or children. Triclopyr is somewhat more toxic to birds than glyphosate, and more toxic to bees. Triclopyr is more toxic to fish than glyphosate is. Aquatic invertebrates are most sensitive to triclopyr and quite tolerant of glyphosate. The data set is not complete for amphibians, aquatic invertebrates or aquatic plants.

## Table 1-1: Comparison of RfDs and TRVs for Glyphosate and Triclopyr

| Taxa and Exposure Type | Glyphosate | Triclopyr BEE |
|---|---|---|
| **Humans** | **(mg/kg)** | **(mg/kg)** |
| acute RfD | 2 | **1.0 (male)**<br>**0.05 (female)** |
| chronic RfD | 2 | **0.05 (male)**<br>**0.012 (female)** |
| **Small Mammals (mouse)** | **(mg/kg)** | **(mg/kg)** |
| acute TRV | 500 | **440** |
| chronic TRV | 500 | **22** |
| **Medium Mammals (squirrel)** | **(mg/kg)** | **(mg/kg)** |
| acute TRV | 500 | **100** |
| chronic TRV | 500 | **5** |
| **Carnivorous Mammals** | **(mg/kg)** | **(mg/kg)** |
| acute TRV | 500 | **20** |
| chronic TRV | 500 | **1** |
| **Birds** | **(mg/kg)** | **(mg/kg)** |
| acute TRV | 1,500 | **126** |
| chronic TRV | 58 | **7.5** |
| **Honeybees** | **(mg/kg)** | **(mg/kg)** |
| honeybees, chronic TRV | 860 | **31** |
| **Plants** | **(lb/acre)** | **(lb/acre)** |
| vegetative vigor TRV, sensitive | 0.035 | **0.0028** |
| seed emergence, TRV sensitive | 4.5 | **0.02** |
| **Sensitive Fish** | **(mg/L)** | **(mg/L)** |
| sensitive fish, acute TRV | 0.5 | **0.091** |
| sensitive fish, chronic TRV | 0.5 | **0.091** |
| **Sensitive Amphibians** | **(mg/L)** | **(mg/L)** |
| acute TRV | 2.2 | **0.1** |
| chronic TRV | 1.8 | **0.1** |
| **Aquatic Invertebrates** | **(mg/L)** | **(mg/L)** |
| acute TRV | 2.7 | **0.045** |
| chronic TRV | 49.9 | **0.045** |
| **Aquatic Plants** | **(mg/L)** | **(mg/L)** |
| tolerant algae TRV | 12.1 | **1** |
| sensitive algae TRV | --- | **0.0014** |

RfD = Reference Dose, a dose for humans below which no adverse effects are anticipated; TRV = Toxicity Reference Value, a dose or exposure below which no adverse effects on terrestrial and aquatic wildlife are anticipated. BEE = butoxyethyl ester; acid = triclopyr carboxylic acid. NA = not available. **Bold** values highlight the most toxic pesticide for a particular taxa group.

***How definitive are the toxicological study results?*** A risk assessment does not provide a precise measure of risk, and even the most thorough risk assessments contain unverified assumptions and data gaps. Risk assessments are useful in highlighting knowledge gaps that require additional studies, trials, or monitoring programs, but do not provide information about risks associated with chemicals for which no toxicity data exist. Results and study parameters often vary from study to study, and multiple studies are necessary to determine where the weight of the evidence lies. Outlier results (i.e., results that are not consistent with the bulk of the studies) may still be important, since most studies involve small numbers of test subjects and may not have the statistical power to reveal infrequent effects. The herbicide risk assessments in this report are based on the available data in the scientific literature and in government reports on the chemicals. The data set is most complete for glyphosate, while triclopyr has more data gaps.

In evaluating toxicological studies, it is important to note that this work is conducted by several different parties, including herbicide manufacturers, consultants and academic scientists hired by herbicide manufacturers, academic scientists funded by government or foundation grants, or government researchers. Where this information is available, the source of the work is included. While US EPA has developed study guidelines for manufacturer-conducted tests used in the pesticide registration process, complete study details are typically not available—only US EPA or USFS summaries of the results are publicly available. Because these studies are only rarely published in the peer-reviewed literature, it is often difficult to confirm their scientific relevance to actual exposure scenarios. See Section 2.5.7 in Chapter 2 for a more detailed discussion of the uncertainties associated with the risk assessments.

***What is the probability that herbicide applications might contaminate drinking water reservoirs in amounts exceeding levels of concern?*** Herbicides do not always stay where they are applied and can move off-site through runoff, leaching through soils, and spray drift. Some Mount Sutro watersheds drain toward Laguna Honda Reservoir, which is used to supply drinking water; however, field reconaissance and stormwater systems maps show that runoff would be captured by San Francisco stormwater systems before reaching the reservoir. While the reservoir is not at risk, wastewater treatment plants would receive contaminated runoff as a result of the project, a scenario that is considered extensively in this risk assessment,

***What is the probability that herbicide applications might lead to contaminated runoff due to spills or rainfall?***
By adhering to the Application Guidelines (see Section 2.5.1A for a listing of these guidelines), applicators can reduce the probability of a large accidental spill occurring to **Highly Improbable**, specifically by preventing large quantities of herbicides (more than 20 gallons) from being transported near Woodland Creek. A small spill (1 gallon) is considered **Improbable** if the Application Guidelines are followed. Peak and long-term runoff are considered **Probable** due to the proposed window for herbicide treatment, June 1 – December 1. This risk can be reduced by applying herbicide as early as possible in the treatment window, and by adhering to buffer zones agreed for triclopyr.

***What is the probability that humans, wildlife and non-target plants will be exposed through non-drinking water routes to herbicides in amounts exceeding levels of concern?*** Herbicide applicators are likely to have the highest exposures, since they would be working directly with

the chemicals. Visitors to Mount Sutro could be exposed through contact with treated plants or nearby soils, rocks and logs. Terrestrial wildlife could be exposed through direct spray contact, by eating contaminated food or drinking contaminated water, and through contact with treated surfaces; aquatic organisms could be exposed if herbicides are spilled into puddles, pools or ruts, or if runoff of herbicide-contaminated water from treated sites occurs. All of these exposure sources are evaluated in this report.

Because the different herbicides may be used at different application rates, the hazard quotients that describe the extent of exposure do not necessarily parallel the inherent toxicity of each herbicide described by Table 1-1. For example, glyphosate and triclopyr were modeled using application rates of 4 (Maximum treatment scenario), 2 (Half-treatment scenario), and 1 (Quarter treatment scenario) pounds per acre.

Table 1-2 shows that the Reference Dose (RfD), the level where adverse health effects may begin to occur, for glyphosate is defined as "2 milligrams of glyphosate per kilogram of body weight per day (mg/kg-day)." The hazard quotient[4] for the most likely exposure scenario for someone who wears contaminated gloves for one minute (an event that is considered to be likely to occur for workers applying herbicde) is 0.000021, which is less than one hundredth of one percent of the reference dose of 2 mg/kg-day.

[4] The hazard quotient is the ratio of the estimated exposure to the toxicity reference value (TRV), which for humans is the same as the reference dose (RfD).

## Table 1-2: Humans—Comparison of Herbicide Risks for Selected Exposure Scenarios

| | | Glyphosate Central Hazard Quotient (HQ)[a] | | Triclopyr BEE Central Hazard Quotient (HQ)[a] | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Man or Child | | Woman[b] | | |
| | Application Rate (lbs/acre) | 4 | 1 | 4 | 1 | 4 | 1 | Scenario Probability |
| **Herbicide Applicators** | **Duration** | | | | | | | |
| **Accidental Exposure to Cut-Stump Treatment Solutions[c]** | | | | | | | | |
| Contaminated gloves | 1 min | 1E-05 | d | 0.25 | d | **5.5** | d | **Pr / Pr** |
| | 1 hr | 0.0009 | d | **15** | d | **327** | d | I / I |
| Spill on hands | 1 hr | 0.0019 | d | 0.028 | d | 0.62 | d | I / I |
| Spill on lower legs | 1 hr | 0.0046 | d | 0.064 | d | **1.4** | d | I / I |
| **Accidental Exposure to Foliar Treatment Solutions[e]** | | | | | | | | |
| Contaminated gloves | 1 min | 1E-06 | d | f | f | f | f | **Pr / Pr** |
| | 1 hr | 9E-05 | d | f | f | f | f | I / I |
| Spill on hands | 1 hr | 0.0002 | d | f | f | f | f | I / I |
| Spill on lower legs | 1 hr | 0.0005 | d | f | f | f | f | I / I |
| **General Handling Exposure Using Backpack Sprayer[g]** | | | | | | | | |
| Cut-stump treatment solutions | 7 hrs | 0.025 | 0.0062 | 0.91 | 0.23 | 0.99 | 0.25 | **HP / HP** |
| Foliar treatment solutions | 7 hrs | 0.026 | 0.0066 | f | f | f | f | **HP / HP** |
| **General Public** | | | | | | | | |
| **Dermal Contact with Contaminated Surface** | | | | | | | | |
| Vegetation contact, shorts & T-shirt, woman | 1 hr | 0.0050 | 0.0012 | f | f | f | f | **I / Po** |
| Sitting on a treated stump in shorts, woman | 1 hr | 0.0004 | 0.0001 | 0.010 | 0.0025 | 0.12 | 0.029 | **I / Po** |
| **Consumption of Contaminated Water from Woodland Creek[h]** | | | | | | | | |
| After a one-gallon spill of 2% foliar solution[i] | N/A | **1.6** | d | f | f | f | f | HI / HI |
| After a one-gallon spill of 20% cut-stump solution[i] | N/A | **16** | d | **32** | d | **702** | d | HI / HI |
| After Peak Herbicide Runoff into Woodland Creek, Maximum Treatment Scenario[j,k] | N/A | 0.0017 | 0.0004 | 0.0001 | 3E-05 | 0.0026 | d | HI / HI |
| After Peak Herbicide Runoff into Woodland Creek, Demonstration Plot #4[l] | N/A | 0.0005 | 0.0001 | 3E-05 | 8E-06 | 7E-04 | d | HI / HI |

**Table 1-2 Notes:**
HQ = Hazard Quotient, the ratio of anticipated exposure to the RfD. RfD = reference dose, the dose at which no adverse effects are anticipated by EPA. BEE = butoxyethyl ester. Hazard Quotients greater than 0.1 are shaded. Hazard Quotients greater than one are also bolded, as are Probable (Pr) and Possible (Po) scenarios.
DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; **Pr** = Probable; **Po** = Possible; I = Improbable; HI = Highly Improbable
Hazard quotients less than 0.0001 are expressed in scientific notation. For example, 0.000008 would be expressed as 8E-6, also expressed as $8 \times 10^{-6}$.

[a] The Central Hazard Quotient is based on central assumptions of exposure and is considered the most likely exposure estimate. Upper and Lower Hazard Quotients, which provide an estimate of worst-case and best-case scenarios, are presented in Chapters 3 and 4.

[b] Triclopyr exposure has been shown to cause birth defects in laboratory animals; therefore, the RfD is lower for women of childbearing age, which leads to a higher estimate of risk for women compared to men by a factor of approximately 20. A woman is considered in most triclopyr exposure scenarios to assess the worst-case scenario.

[c] The Central exposure estimate for cut-stump treatment solutions is for the herbicide products Aquamaster and Garlon 4 Ultra diluted to 20% product by volume.

[d] Spill and spray exposures are on a per-event basis and do not change with herbicide application rate.

[e] The Central exposure estimate for foliar treatment solutions is for the herbicide products Aquamaster and Garlon 4 Ultra diluted to 2% product by volume.

[f] No foliar application of triclopyr is under consideration for the Mount Sutro project.

[g] For general handling exposure for workers, the chronic RfD is used for comparison because it is assumed that workers are handling herbicide on a regular basis.

[h] A child is considered in the general public estimates for glyphosate to provide a worst-case scenario. Unlike for triclopyr, the glyphosate RfD is the same for any human.

[i] A one-gallon spill into Woodland Creek resulted in the lowest Central risk estimates of any spill scenario; other spills considered in the risk assessment (20-gallon spills, spills into a puddle or pool) would all lead to exposures higher than the RfDs as well. Triclopyr values are presented here for 20% cut-stump solution only because no foliar treatment with triclopyr is proposed. Comprehensive spill scenarios are presented in Chapters 3 and 4.

[j] Herbicide concentrations in long-term runoff are predicted to be lower than for peak runoff, and do not exceed levels of concern. Herbicide concentrations for long-term runoff are presented in Chapters 3 and 4.

[k] The Maximum treatment scenario is all acres treated at the Maximum application rate of 4 lbs a.e./acre.

[l] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

## Table 1-3: Terrestrial Wildlife—Comparison of Herbicide Risks for Selected Exposure Scenarios

| | Receptor | Central Hazard Quotient (HQ)[a] Glyphosate | Triclopyr BEE | Triclopyr Acid | TCP | Scenario Probability |
|---|---|---|---|---|---|---|
| **Direct Spray of Small Mammal, 50% of Body Surface, First-Order Absorption** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | | 0.095 | 0.79 | b | b | **I / Po** |
| Foliar treatment solution, 2% herbicide concentration | | 0.0019 | c | c | c | **I / Po** |
| **Acute Consumption of Contaminated Fruit, Vegetation, Insects or Small Mammals as 30% of Diet** | | | | | | |
| Consumption of contaminated fruit | Small mammal | 0.0028 | 0.0032 | b | b | **Po / Po** |
| Consumption of contaminated vegetation (grass) | Small mammal | 0.034 | c | c | c | **Po / Po** |
| | Large bird | 0.024 | c | c | c | I / I |
| Consumption of contaminated insects | Small mammal | 0.056 | 0.063 | b | b | **Po / Po** |
| | Small bird | 0.030 | 0.36 | b | b | **Po / Po** |
| Consumption of contaminated small mammal | Carnivorous mammal | 0.0050 | 0.13 | b | b | **I / Po** |
| | Carnivorous bird | 0.0026 | 0.031 | b | b | **I / Po** |
| **Consumption of Water After a Spill into a 50-Liter Puddle/Pool of One Gallon of Herbicide[d]** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | Small mammal | **2.1** | **2.4** | d | d | I / I |
| | Carnivorous mammal | **1.2** | **31** | d | d | I / I |
| | Small bird | **1.3** | **16** | d | d | I / I |
| | Large bird | 0.2 | **2.2** | d | d | I / I |
| Foliar treatment solution, 2% herbicide concentration | Small mammal | 0.21 | c | c | c | I / I |
| | Carnivorous mammal | 0.12 | c | c | c | I / I |
| | Small bird | 0.13 | c | c | c | I / I |
| | Large bird | 0.018 | c | c | c | I / I |
| **Consumption of Contaminated Water After a Spill into Woodland Creek of 10 Gallons of Herbicide[d]** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | Small mammal | **12** | **14** | b | b | I / I |
| | Carnivorous mammal | **7.2** | **180** | b | b | I / I |
| | Small bird | 0.077 | 0.91 | b | b | I / I |
| | Large bird | 0.011 | 0.13 | b | b | I / I |
| Foliar treatment solution, 2% herbicide concentration | Small mammal | **1.2** | c | c | c | I / I |
| | Carnivorous mammal | 0.72 | c | c | c | I / I |
| | Small bird | 0.0077 | c | c | c | I / I |
| | Large bird | 0.0011 | c | c | c | I / I |
| **Consumption of Contaminated Water After Peak Herbicide Runoff into Woodland Creek[e]** | | | | | | |
| **Maximum Treatment Scenario[f]** | Small mammal | 1E-05 | 5E-07 | 4E-05 | 2E-05 | **Pr / Pr** |
| | Carnivorous mammal | 7E-06 | 7E-06 | 0.0005 | 1E-05 | **Pr / Pr** |
| | Small bird | 8E-06 | 3E-06 | 0.0003 | 8E-05 | **Pr / Pr** |
| | Large bird | 1E-06 | 5E-07 | 4E-05 | 1E-05 | **Pr / Pr** |
| **Demonstration Plot #4[g]** | Small mammal | 4E-06 | 2E-07 | 1E-05 | 6E-06 | **Pr / Pr** |
| | Carnivorous mammal | 2E-06 | 2E-06 | 0.0001 | 3E-06 | **Pr / Pr** |
| | Small bird | 2E-06 | 1E-06 | 7E-05 | 2E-05 | **Pr / Pr** |
| | Large bird | 3E-07 | 1E-07 | 1E-05 | 3E-06 | **Pr / Pr** |

**Table 1-3 Notes:**
HQ = Hazard Quotient, the ratio of anticipated exposure to the TRV. TRV = Toxicity Reference Value, the dose below which no adverse effects are anticipated in a wildlife population. Hazard Quotients greater than 0.1 are shaded. Hazard Quotients greater than one are bolded, as are Probable (Pr) and Possible (Po) scenarios. Hazard quotients less than 0.0001 are expressed in scientific notation. For example, 0.000008 would be expressed as 8E-6, also expressed as $8 \times 10^{-6}$.
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.
Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; **Pr** = Probable; **Po** = Possible; I = Improbable; HI = Highly Improbable

[a] The Central Hazard Quotient is based on central assumptions of exposure and is considered the most likely exposure estimate. Upper and Lower Hazard Quotients, which provide an estimate of worst-case and best-case scenarios, are presented in Chapters 3 and 4.

[b] Triclopyr acid and TCP are degradation products of triclopyr BEE; they are not present in acute exposures such as direct sprays and spills.

[c] No foliar application of triclopyr is under consideration for the Mount Sutro project.

[d] A ten-gallon spill into Woodland Creek resulted in the lowest Central risk estimates of any spill scenario; other spills considered in the risk assessment (20-gallon spills, spills into a puddle or pool) would all lead to exposures higher than the TRVs as well. Triclopyr values are presented here for 20% cut-stump solution only because no foliar treatment with triclopyr is proposed. Comprehensive spill scenarios are presented in Chapters 3 and 4.

[e] Herbicide concentrations in long-term runoff are predicted to be lower than for peak runoff, and predicted concentrations do not exceed 10 percent of any TRV. Concentrations for long-term runoff are presented in Chapters 3 and 4.

[f] The Maximum treatment scenario is all acres treated at the Maximum application rate of 4 lbs a.e./acre.

[g] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

## Table 1-4: Aquatic Wildlife—Comparison of Herbicide Risks for Selected Exposure Scenarios

| | Receptor | Central Hazard Quotient (HQ)[a] | | | | Scenario Probability |
|---|---|---|---|---|---|---|
| | | Glyphosate | Triclopyr BEE | Triclopyr Acid | TCP | |
| **Exposure to Contaminated Water After Spill into Woodland Creek of One Gallon of Herbicide[b]** | | | | | | |
| Cut-stump treatment solution, 20% herbicide concentration | Sensitive amphibians | **194** | **4,268** | c | c | HI / HI |
| | Sensitive fish | d | d | d | d | d |
| | Sensitive aquatic invertebrates | **158** | **9,484** | c | c | HI / HI |
| | Aquatic plants | **35** | **304,836** | c | c | HI / HI |
| Foliar treatment solution, 2% herbicide concentration | Sensitive amphibians | **19** | c | c | c | HI / HI |
| | Sensitive fish | d | d | d | d | d |
| | Sensitive aquatic invertebrates | **16** | c | c | c | HI / HI |
| | Aquatic plants | **3.5** | c | c | c | HI / HI |
| **Exposure to Contaminated Water After Peak Herbicide Runoff** | | | | | | |
| **Maximum Treatment Scenario[e]** | | | | | | |
| Peak runoff to Oceanside WWTP[f] | Sensitive amphibians | d | d | d | d | d |
| | Sensitive fish | 0.0005 | 0.0015 | 0.0001 | 0.0001 | **Pr / Pr** |
| | Sensitive aquatic invertebrates | 9E-05 | 0.0031 | 8E-06 | 3E-05 | **Pr / Pr** |
| | Aquatic plants | 2E-05 | 0.099 | 0.0008 | 5E-05 | **Pr / Pr** |
| Peak runoff into Woodland Creek[f] | Sensitive amphibians | 0.020 | 0.016 | 0.0010 | 0.020 | **Pr / Pr** |
| | Sensitive fish | d | d | d | d | d |
| | Sensitive aquatic invertebrates | 0.016 | 0.036 | 0.0048 | 0.0065 | **Pr / Pr** |
| | Aquatic plants | 0.0036 | **1.1** | 0.52 | 0.010 | **Pr / Pr** |
| **Demonstration Plot #4[g]** | | | | | | |
| Peak runoff to Oceanside WWTP[f] | Sensitive amphibians | d | d | d | d | d |
| | Sensitive fish | 0.0001 | 0.0004 | 3E-05 | 3E-05 | **Pr / Pr** |
| | Sensitive aquatic invertebrates | 3E-05 | 0.0009 | 2E-06 | 1E-05 | **Pr / Pr** |
| | Aquatic plants | 6E-06 | 0.028 | 0.0002 | 1E-05 | **Pr / Pr** |
| Peak runoff into Woodland Creek[f] | Sensitive amphibians | 0.0056 | 0.0045 | 0.0003 | 0.0056 | **Pr / Pr** |
| | Sensitive fish | d | d | d | d | d |
| | Sensitive aquatic invertebrates | 0.0046 | 0.010 | 0.0014 | 0.0018 | **Pr / Pr** |
| | Aquatic plants | 0.0010 | 0.32 | 0.15 | 0.0028 | **Pr / Pr** |

**Table 1-4 Notes:**
HQ = Hazard Quotient, the ratio of anticipated exposure to the TRV. TRV = Toxicity Reference Value, the dose below which no adverse effects are anticipated in a wildlife population. WWTP = Wastewater treatment plant. Hazard Quotients greater than 0.1 are shaded. Hazard Quotients greater than one are bolded, as are Probable (Pr) and Possible (Po) scenarios. Hazard quotients less than 0.0001 are expressed in scientific notation. For example, 0.000008 would be expressed as 8E-6, also expressed as $8 \times 10^{-6}$.
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.

Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; **Pr** = Probable; **Po** = Possible; I = Improbable; HI = Highly Improbable

[a] The Central Hazard Quotient is based on central assumptions of exposure and is considered the most likely exposure estimate. Upper and Lower Hazard Quotients, which provide an estimate of worst-case and best-case scenarios, are presented in Chapters 3 and 4.

[b] A one-gallon spill into Woodland Creek resulted in the lowest Central risk estimates of any spill scenario; other spills considered in the risk assessment (20-gallon spills, spills into a puddle or pool) would all lead to exposures higher than the RfDs as well. Triclopyr values are presented here for 20% cut-stump solution only because no foliar treatment with triclopyr is proposed. Comprehensive spill scenarios are presented in Chapters 3 and 4.

[c] Only triclopyr BEE is considered for acute spill scenarios because degradation to triclopyr acid and TCP occurs only over a longer time frame.

[d] Fish are not found in the seasonal Woodland Creek, so were not evaluated. The WWTP scenarios were not evaluated for amphibians because amphibians only live in fresh water.

[e] The Maximum treatment scenario is all acres treated at the maximum application rate of 4 lbs a.e./acre.

[f] Herbicide concentrations at Southeast WWTP are predicted to be lower than at Oceanside WWTP because less of the treated area drains to the east. Herbicide concentrations in long-term runoff are predicted to be lower than for peak runoff and predicted concentrations do not exceed 10 percent of any TRV. Concentrations at both WWTPs and for long-term runoff are presented in Chapters 3 and 4.

[g] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

# Chapter 2 — Essential Background

# Table of Contents — Chapter 2: Essential Background

**TABLE OF TABLES** ..... **4**

**2.1 INTRODUCTION** ..... **5**

2.1.1 VEGETATION REMOVAL METHODS ..... 6
2.1.1.A Brontosaurus Brush Mower ..... 6
2.1.1.B Cut-stump Herbicide Application ..... 6
2.1.1.C Factors Affecting Risks Associated with Cut-Stump Treatments ..... 8
2.1.1.D Triclopyr-Based Cut-stump Treatment ..... 9
2.1.1.E Glyphosate-Based Cut-stump Treatment ..... 9
2.1.2 EFFICACY OF TREATMENT ..... 10

**2.2 ASSESSING THE IMPACTS OF CHEMICALS ON HUMANS** ..... **14**

2.2.1 OVERVIEW OF US EPA'S PROCESS FOR ASSESSING RISK TO HUMANS ..... 14
2.2.2 ROUTES AND SOURCES OF EXPOSURE ..... 15
2.2.3 BIOMONITORING ..... 16
2.2.4 PESTICIDE ILLNESS SURVEILLANCE ..... 16
2.2.5 ACUTE EFFECTS OF PESTICIDE EXPOSURE ..... 19
2.2.6 CHRONIC HEALTH EFFECTS OF PESTICIDE EXPOSURE ..... 19
2.2.6.A Cancer ..... 19
2.2.6.B Reproductive Outcome ..... 20
2.2.7 EPIDEMIOLOGY ..... 21
2.2.7.A Prospective Studies ..... 21
2.2.7.B Retrospective Studies ..... 22
2.2.7.C Risk Ratios ..... 22
2.2.7.D Other Factors ..... 22
2.2.7.E Testing Statistical Significance ..... 23

**2.3 ASSESSING IMPACTS OF CHEMICALS ON ANIMALS AND OTHER ORGANISMS** ..... **24**

2.3.1 OVERVIEW OF THE PROCESS FOR ASSESSING RISKS TO ANIMALS AND OTHER ORGANISMS ..... 24
2.3.2 ROUTES OF EXPOSURE ..... 25
2.3.3 DEFINITIONS OF TERMS USED ..... 25
2.3.4 WILDLIFE TOXICITY REFERENCE TABLES ..... 27
2.3.5 INDIRECT EFFECTS OF HERBICIDE APPLICATIONS ..... 29
2.3.6 ENDOCRINE DISRUPTION ..... 29

**2.4 ASSESSING THE FATE OF CHEMICALS IN THE ENVIRONMENT** ..... **31**

2.4.1 HOW PHYSICAL PROPERTIES AFFECT ENVIRONMENTAL FATE ..... 31
2.4.2 FATE AND TRANSPORT PROCESSES ..... 33

**2.5 EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION** ..... **34**

2.5.1 APPLICATION GUIDELINES AND EXPOSURE SCENARIO CATEGORIZATION ..... 36
2.5.1.A UCSF Sutro Forest Vegetation Management Guidelines ..... 36
2.5.1.B Application Schedule and Treatment Limitations ..... 39
2.5.1.C Exposure Scenario Categorization and Probabilities ..... 41
2.5.2 WATER CONTAMINATION SCENARIOS ..... 51
2.5.2.A Site-Specific Weather Patterns near Mount Sutro ..... 51
2.5.2.B USFS/SERA Water Contamination Rates from GLEAMS Modeling ..... 55
2.5.2.C Why the USFS/SERA Model Might Overestimate Herbicide Concentrations in Water ..... 55
2.5.2.D Why the USFS/SERA Model Might Underestimate Herbicide Concentrations in Water ..... 56
2.5.2.E Accidental Spills ..... 56
2.5.2.F Peak Runoff Based on USFS/SERA Water Contamination Rates ..... 58
2.5.2.G Long-term Runoff Based on USFS/SERA Water Contamination Rates ..... 58
2.5.2.H Short-term Runoff to Wastewater Treatment Plants ..... 59
2.5.3 HUMAN EXPOSURE SCENARIOS ..... 62
2.5.3.A Worker Exposure ..... 63

2.5.3.B Exposures to the General Public ..... 68
2.5.3.C Aggregate Exposures ..... 71
2.5.4 TERRESTRIAL WILDLIFE EXPOSURE SCENARIOS ..... 71
2.5.4.A Notes on Wildlife Exposure Parameters ..... 72
2.5.4.B Dermal Exposure for Terrestrial Animals ..... 73
2.5.4.C Exposures from Consumption of Contaminated Vegetation or Prey ..... 75
2.5.4.D Exposures from Consumption of Contaminated Water ..... 77
2.5.5 AQUATIC WILDLIFE EXPOSURE SCENARIOS ..... 78
2.5.6 RISK CHARACTERIZATION ..... 78
2.5.7 UNCERTAINTIES ASSOCIATED WITH RISK ASSESSMENTS ..... 80
2.5.7.A Toxicity Assessment Uncertainties ..... 81
2.5.7.B Exposure Assessment Uncertainties ..... 82

**REFERENCES FOR CHAPTER 2 ..... 84**

## Table of Tables

Table 2-1: Trees Treated Per Acre as a Function of Product Concentration....9
Table 2-2: Efficacy of Cut-stump/Cut-stem Treatment Method Studies....11
Table 2-3: Respirable Particle Sizes....16
Table 2-4: Reference Toxicity Values for Mammals....28
Table 2-5: Reference Toxicity Values for Birds: Dose per Unit Body Weight....28
Table 2-6: Reference Toxicity Values for Birds: Concentration in Food....28
Table 2-7: Reference Toxicity Values for Amphibians, Fish, and Aquatic Invertebrates....29
Table 2-8: Mount Sutro Herbicide Treatment Schedule....40
Table 2-9: Water Contamination Scenarios and Probability of Occurrence....42
Table 2-10: Worker Exposure Scenarios and Probability of Occurrence....44
Table 2-11: General Public Exposure Scenarios and Probability of Occurrence....45
Table 2-12: Wildlife Exposure Scenarios and Probability of Occurrence....47
Table 2-13: Water Body and Spill Parameters Used for Mount Sutro Exposure Scenarios....53
Table 2-14: Typical Absorbed Doses For Various Application Methods....65
Table 2-15: Dermal Exposure Parameters....67
Table 2-16: Water Consumption Parameters....71
Table 2-17: Food Intake Predicted by Allometric Relationships....72
Table 2-18: Water Intake Predicted by Allometric Relationships....72
Table 2-19: Surface Area Predicted by Allometric Relationships....73
Table 2-20: Scenarios for Mammals and Birds Eating Contaminated Fruit or Vegetation....76
Table 2-21: Fraction of Applied Herbicide Drifted as a Function of Distance....77
Table 2-22: Herbicide Residues and Caloric Density of Food....77
Table 2-23: US EPA's Interpretation of Hazard Quotients for Threatened and Endangered Species....80

## 2.1 Introduction

In this section of the report, essential background information is presented to provide context for understanding the risk assessment. The two herbicides that are proposed for use on Mount Sutro are Aquamaster (containing glyphosate isopropylamine salt and water) and Garlon 4 Ultra (containing triclopyr butoxyethyl ester (BEE), as well as a methylated seed oil adjuvant). Competitor was selected as the surfactant to be used in combination with Aquamaster, containing a mixture of ethyl oleate, sorbitan alkylpolyethoxylate, and dialkyl polyoxyethylene glycol. Chapter 2 provides general information applicable to all chemicals evaluated; information specific to individual chemicals is provided in Chapters 3 (glyphosate), 4 (triclopyr) and 5 (surfactant ingredients).

Risk characterizations for each herbicide are presented for two Demonstration Projects and for the Main Project scenario as described in the Notice of Preparation/Initial Study.[1] See Figure 2-1 for locations of the Demonstration Projects. Initially, herbicides would be used in one acre of Demonstration Project 1 ("South Ridge Area"), but not used in Demonstration Projects 2 ("Edgewood Avenue Area") and 3 ("North Side of Summit"). It will not be known whether herbicides would be used in the two-acre Demonstration Project 4 ("East Bowl Corridor") until after an outcome for Project 1 is complete; so, for the purpose of conservative analysis, it is assumed here that herbicides would be used. Section 2.5 below addresses differences, if any, in the method of analysis for these two situations. In many cases, hazard quotients are calculated on a per-acre basis. These per-acre hazard quotients typically do not differ when comparing the Main Project to the Demonstration Project, with limited exceptions discussed individually below.

**Figure 2-1:** Location of Demonstration Projects on Mount Sutro.

Much of the toxicity information in Chapters 3 and 4 is drawn from the United States Forest Service (USFS) risk assessments for glyphosate and triclopyr,[2] US EPA's re-registration decision documents,[3] Registration Review documents[4] or Endangered Species Effects Determinations.[5] Other data sources used include the EPA Ecotox databases[6] (Terretox for the terrestrial database

and AQUIRE for the aquatic database), the US National Toxicology Program study reports[7] and the World Health Organization (WHO) Environmental Health Criteria.[8] An extensive, but not exhaustive, survey of the peer-reviewed literature was also conducted to complement the USFS risk assessment and update the peer-reviewed literature to 2011. This document was developed to make the Mount Sutro risk assessment site-specific. The toxicology and environmental fate information on the chemicals is intended to supplement, not replace the USFS risk assessment.

### 2.1.1 Vegetation Removal Methods

The UCSF Mount Sutro project description calls for clearing eucalyptus trees and understory brush and vines using mechanical methods, followed by treatment of cut-stumps with herbicides to prevent resprouting. This section provides additional background on the clearing methods and efficacy of herbicide treatments as they apply to the risk assessments in this report.

#### *2.1.1.A Brontosaurus Brush Mower*

The equipment proposed for use in the Mount Sutro project, the Brontosaurus Brush Mower, is a cutting tool for grinding and mulching trees and vegetation in-place.[9] The Brontosaurus mowing head can be mounted on "an excavator, gradall, feller-buncher, high-flow skid steer or custom machine," according to the manufacturer. The University of California Berkeley's Fire Fuel Management Project used a Brontosaurus for eucalyptus removal in the Berkeley hills in 2004, and authored a report on the efficacy of the project, which has similarities to the proposed project at Mount Sutro.[10] The Brontosaurus was reported to be "most productive in areas requiring heavy brush removal and containing eucalyptus stems, if any, of generally less than 10" diameter at breast height." The Berkeley project staff found that slopes up to thirty percent could be navigated by the Brontosaurus, but its speed and thus productivity typically dropped as slope increased.

Understory vegetation would be cut before the trees in order to allow herbicide application before the stems are buried by the additional mulch generated by the tree removal. These understory plants would be cut with a Brontosaurus where possible, and otherwise by hand crews.

The UC Berkeley report notes that stumps under five inches in diameter were "covered up in a mix of wood chips and poison oak debris," making them difficult to detect and treat; however, re-sprouts that pushed through the layer of mulch could be detected and treated. The mulch will also have a beneficial effect, similar to tarping, for reducing the rate of re-sprouting by blocking access to sunlight.

The current risk assessment assumes that after initial cutting, some re-sprout treatments will be needed the following year, with the limits of treatment set by the maximum allowable herbicide application rate for the project outlined in UCSF Sutro Forest Vegetation Management Guidelines, Section 2.5.1.A below.

#### *2.1.1.B Cut-stump Herbicide Application*

Herbicides can be applied using a wide variety of methods, including foliar, soil-based, cut-stump, basal bark, and injection.[11] The following discussion of herbicide application rates and

methods will be limited to the methods proposed for use on Mount Sutro: Cut-stump (called "cut-stem" for brush treatments) and directed spot spray treatment of re-sprouting vegetation.

The US Forest Service does not model cut-stump application in its risk assessment methodologies for glyphosate and triclopyr, nor does it model any treatment methods involving the treatment of "noncontiguous areas" because of a lack of data on worker exposure rates and the amount of material that a worker might handle using these methods.[12] However, the UC Berkeley report[10] provided relevant data that made it possible to estimate general worker exposure for the Mount Sutro risk assessment for cut-stump treatments (see Section 2.5.3.A).

The cut-stump method requires herbicide to be applied to stumps using a brush, backpack sprayer, squirt bottle, wick applicator or cutting tool-integrated applicator. The method is most effective when a stump is freshly cut (typically within 30 minutes), so most advice on application rates and methods focuses on immediate treatment. Water-based solutions of herbicide are sufficient if applied when a cut is fresh, whereas an oil mixture with herbicide is typically used for stumps not freshly cut.[13] Only the cambium and phloem—typically the outer two to three inches—of a stump needs to be treated (Figure 2-2). These parts of the stump transport the herbicide down into the roots. For stumps and stems less than four to six inches in diameter, the entire cut surface is treated (Figure 2-3).[14] (Applied in this way, rates of herbicide use will grow linearly, rather than as a squared function, with increasing tree diameter.[a]) Use of a clearing saw that immediately delivers herbicide onto the cut surface after felling can expedite cut-stump treatment and maximize effectiveness by treating as quickly as possible after cutting.[15] USFS refers to this type of application, when a cutting tool is first dipped in concentrated herbicide, as "dip and clip";[16] this approach may be useful for stumps too large in diameter for a Brontosaurus.

**Figure 2-2:** Cut-stump application on the cambium of the tree, consisting of the outer two to three inches of the stump. Blue dye is mixed with the herbicide to mark the treated area.[17]

[a] Treated area = total area of stump - untreated area = $\pi r^2 - \pi(r-3)^2 = \pi(6r-9)$ where r = radius of stump; (r-3) = radius of the inner untreated area, assuming a three-inch-wide band of herbicide treatment.

**Figure 2-3:** Paint brush application of glyphosate to a freshly cut Siberian elm stump.[18]

### *2.1.1.C Factors Affecting Risks Associated with Cut-Stump Treatments*

For cut-stump treatments, herbicide product labels typically recommend using a 50–100 percent solution of a highly concentrated formulated product. However, using highly concentrated solutions of herbicide amplifies the potential for adverse effects to workers, the general public and wildlife from accidental spills, general handling exposure, and imprecise applications that result in contamination of adjacent areas and higher runoff to water bodies. The amount of contamination of the adjacent area is affected primarily by three variables: 1) the concentration of the herbicide solution used, 2) the precision of the method of application, and 3) the amount of herbicide applied per cut stump.

In a study on removal of invasive fig groves, Holmes and Berry[19] concluded that the use of basal bark methods (which are similar to cut-stump treatments) on densely spaced trees can lead to annual application rates three to five times greater than the label limit on a per-acre basis. They used a solution of 25 percent triclopyr herbicide and 75 percent methylated seed oil to treat freshly cut fig stumps. While the treatment was effective, they found high residues of triclopyr (up to 6.6 ppm) near the treated stems six months after the treatment. The soil concentrations of triclopyr dropped off with distance, decreasing from an average of 3.2 ± 0.8 ppm within 0.5 meters of the treated area to 0.28 ± 0.09 ppm at distances between 0.5 meters from the treated area and the edge of the canopy dripline. These residues were sufficient to inhibit the survival of native plants transplanted into the treated area nearly six months after treatment, with 16 percent mortality observed in the treated areas, compared to zero percent for the untreated control site.

In another study, Nowak and Ballard[20] evaluated off-target herbicide deposition as a function of application method, using four common application methods: basal bark, cut-stump, high-volume (hydraulic) foliar and low-volume (backpack) foliar. Basal and cut-stump treatments produced small areas of off-target contamination, but the amount of herbicide deposited off-

target was hundreds to thousands of times higher than for foliar treatments. Foliar treatments created larger areas of off-target contamination, but with relatively low amounts of herbicide per unit area. On a per-tree basis, off-target herbicide deposits via basal bark or cut-stump were 68 times that of backpack foliar treatment, and six times that of hydraulic foliar treatment. On a per-acre basis for the area actually treated, the difference in deposition was much greater: cut-stump and basal bark methods led to deposition 200 times greater than backpack foliar, and 4,000 times greater than hydraulic foliar. The difference in deposition between foliar and cut-stump sprays is due to the fact that the cut-stump/basal bark spray solutions were 20 times more concentrated than the foliar spray solution, and the cut-stump/basal bark applications were focused on a smaller target area. The authors noted that the use of foliar spray equipment to treat cut-stumps was an additional contributor to the off-target deposition of herbicide and suggested that more directed techniques could significantly reduce it.

The amount of herbicide applied per stump is another factor in determining potential for off-target effects. UC Berkeley reported using an average of three ounces of a 30 percent solution of Garlon 4 (diluted with diesel fuel) to treat each stump in their vegetation management project.[10] More dilute solutions (5–20 percent) and lower application rates (down to approximately one ounce per 12-inch stump) have also been used successfully (see Section 2.1.2 for a discussion of herbicide efficacy). The maximum number of trees that can be treated per acre without exceeding 4 pounds of herbicide acid equivalent (a.e.) per acre is shown in Table 2-1 for Aquamaster or Garlon 4 Ultra at treatment rates of 3 oz/stump and 1 oz/stump, and at varying concentrations.

**Table 2-1: Trees Treated Per Acre as a Function of Product Concentration**

| Product Concentration (%)* | Maximum Number of Trees Treated per Acre | |
|---|---|---|
| | 3 oz/Stump | 1 oz/Stump |
| 5 | 853 | 2,560 |
| 10 | 427 | 1,280 |
| 20 | 213 | 640 |
| 50 | 86 | 256 |
| 100 | 43 | 128 |

* For glyphosate- or triclopyr-containing herbicide products containing 4 lbs acid equivalent (a.e.) per gallon, this number represents the dilution of the pure product.

#### *2.1.1.D Triclopyr-Based Cut-stump Treatment*

Triclopyr butoxyethyl ester (BEE) is proposed for use on Mount Sutro to treat the stumps of cut trees, primarily eucalyptus. The product label for Garlon 4 Ultra states that, for forestry applications, triclopyr must be limited to six quarts (six pounds acid equivalent) per acre per year.[21] USFS lists a "typical" application rate of triclopyr as one pound acid equivalent (a.e.) per acre and its most intensive use "rarely exceeds" six pounds acid equivalent per acre.[22] For the Mount Sutro project, UCSF will be limiting its annual use to a maximum of four pounds a.e. per acre.

#### *2.1.1.E Glyphosate-Based Cut-stump Treatment*

In the Mount Sutro project, glyphosate will be used primarily for woody vegetation like blackberries, poison oak, and English ivy; however, some trees may be treated with this herbicide as well. Glyphosate is not effective on stumps that have started to dry after cutting,[13] so

other herbicides should be used if immediate treatment is impossible. Once inside the plant, glyphosate is translocated to all parts of the plant, including the roots. This property can result in herbicide injury to adjacent plants that have roots grafted to those of the treated plant.

Monsanto's product label for Aquamaster states that the maximum application rate is eight pounds of glyphosate as acid equivalent (a.e.) per acre per year, and recommended concentrations are from 50 to 100 percent.[15] A Canadian survey of cut-stump studies provided results from more than a dozen publications in which solutions with concentrations of glyphosate ranging from five to twenty percent were still effective in preventing re-sprouts, with higher efficacy for the more dilute solutions observed for winter applications, compared to summer and spring (see Section 2.1.2). For the Mount Sutro project, UCSF will be limiting its annual use of glyphosate to a maximum of four pounds a.e. per acre.

### 2.1.2 Efficacy of Treatment

The efficacy of an herbicide treatment is a measure of the initial kill rate after treatment, combined with the incidence of re-sprouting that typically occurs months after treatment. The efficacy of cut-stump treatments depends on many variables, including the selection of an appropriate herbicide and application method for a particular species, the concentration of herbicide and adjuvants applied, the season of application, and environmental factors such as the occurrence of rain after an application. Numerous studies document the efficacy of cut-stump treatments using particular herbicides and application methods for a variety of species. Table 2-2 summarizes the studies relevant to the herbicides under consideration. A document published by the Ontario Ministry of Natural Resources summarized more than a dozen studies on cut-stump treatment, many of which involved glyphosate and/or triclopyr, and are included in Table 2-2.[32] Note that some of the studies mentioned below included herbicides other than glyphosate and/or triclopyr, but only these two herbicides are under consideration at Mount Sutro.

**Table 2-2: Efficacy of Cut-stump/Cut-stem Treatment Method Studies**

| Formulation | Concentration[a] (%) | Success rate[b] (%) | Species | Description[c] | Location | Time after Treatment[d] | Notes | Reference |
|---|---|---|---|---|---|---|---|---|
| **Triclopyr BEE (Garlon 4)** | 80% | "Highest of herbicides tested" | Blue gum eucalyptus (*Eucalyptus globulus*) | 150-180 feet tall, "large, solitary, waxy buds and fruits." | Angel Island, Marin County, CA | Unknown | Per edited volume summary of journal article | Boyd in Bossard et al., eds. 2000[23] |
| **Glyphosate (Roundup)** | 5% | 100% | | | Jepson Prairie preserve, Solano County, CA | "by the third application" | Glyphosate not applied to stumps but to re-sprouts. | |
| **Triclopyr TEA (Garlon 3A)** | 50% | 86-100% | Shoebutton Ardisia (*Ardisia elliptica*) | Evergreen shrub or small tree" to 17 feet in height | Florida | 12 months | Success defined as no resprouting | Siso and Burzycki 2004[24] |
| **Triclopyr TEA and BEE (Garlon 3A and Garlon 4)** | 50% | 95-100% | Yellow Himalayan raspberry (*Rubus ellipticus Sm.*) | "A robust shrub" that may climb on other plants, height to 5 meters | Hawaii | 24 months | "No significant difference between imazapyr, metsulfuron, triclopyr amine, and triclopyr ester at inhibiting resprout initiation" | Santos et al., 1991[25] |
| **Triclopyr BEE (Garlon 4)** | 50% | 41%[e] | Chinese tallowtree (*Sapium sebiferium)* | > 2.4 cm DBH | South Carolina | 12 months | 'Hack and squirt', rather than cut-stump | Gresham 2010[26] |
| **Glyphosate (AquaNeet)** | 100% | 62%[e] | | | | | | |
| **Imazapyr (Habitat)** | 50% | 96%[e] | | | | | | |
| **Glyphosate (Glypro)** | 50%–100% | 100% stump sprouts; 90% root sprouts | American beech (*Fagus grandifolia Ehrh.*) | >6" DBH were treated | West Virginia | 12 months | Species naturally "does not sprout vigorously from larger stumps" | Kochenderfer et al. 2006 [27] |
| **Glyphosate (Roundup 360)** | 100% | See Notes | Broad-leaved pepper trees (*Schinus terebinthifolius Raddi*) | Evergreen shrub or small tree, usually 2 to 6 m in height and 3 to 12 cm in stem diameter[28] | Queensland, Australia | 26 months | "Seemed to give total or near-total kills at 12 months after application, [but] by 26 months suckering had occurred in all treatments." | Panetta and Anderson 2001[29] |
| **Glyphosate (Roundup 360)** | 100% | 90% | *Eucalyptus obliqua* | 5-32 cm DBH at study sites | Tasmania | 12 months at "dry" site, 3 months at "wet" site | Injection, not cut-stump | LaSala and Dingle 2000[30] |

| Formulation | Concentration[a] (%) | Success rate[b] (%) | Species | Description[c] | Location | Time after Treatment[d] | Notes | Reference |
|---|---|---|---|---|---|---|---|---|
| **Glyphosate (Roundup Ultramax and Aquamaster)**<br>**Triclopyr TEA (Garlon 3A)** | 100% for all | 100% for all | Butterfly bush (*Buddleja davidii*) | Approx 2 m (6.6 ft) tall and wide, and flowers profusely when treated | Oregon | 9 months approximately ("following spring" after July planting) | Maximum labeled rate was applied to all | Altland and Ream 2010[31] |
| **Triclopyr**<br>**Glyphosate** | NR[f] | "Both herbicides provided excellent control" | Bigleaf maple | NR[f] | NR[f] | NR[f] | The form of the active ingredient (salt, acid or ester) was unspecified. | Comeau et al. 1993 in Mallik *et al.* 1997[32] |
| **Triclopyr BEE** | 3.3% with diesel fuel | 94% | Sugar maple<br>Birch<br>Aspen<br>Pin cherry | NR[f] | NR[f] | NR[f] | | ECW 1982 and ECW 1989 in Mallik *et al.* 1997[32] |
| **Glyphosate** | 25% with water | 100% | Aspen<br>White birch<br>Pin cherry | NR[f] | NR[f] | NR[f] | | ECW 1982 in Mallik *et al.* 1997[32] |
| **Glyphosate** | 20% with water | 100% | Aspen<br>Birch | NR[f] | NR[f] | NR[f] | | Bons 1984 in Mallik *et al.* 1997[32] |
| | 10% with water | "Partial control" | | | | | | |
| **Glyphosate** | 5% with water | 100% | Eucalyptus | NR[f] | Western Australia | NR[f] | 2 mL applied per 2.5 cm stem diameter | Fremlin and Jones 1984 in Mallik *et al.* 1997[32] |
| **Triclopyr BEE (Garlon 4; Garlon RTU)** | Diluted with diesel fuel and kerosene, concentration NR[f] | 100% ? | Pin cherry<br>Black locust<br>White oak<br>Northern red oak | NR[f] | NR[f] | NR[f] | "All species successfully controlled with these herbicide formulations" | Haagsma *et al.* 1982 in Mallik *et al.* 1997[32] |
| **Triclopyr BEE** | NR[f] | "Nearly all" | Maple<br>Ash<br>Pin cherry<br>Birch<br>Northern red oak | NR[f] | NR[f] | 13 at one site; 32 months at second site | | MacKasey and Allen 1983 in Mallik *et al.* 1997[32] |

| Formulation | Concentration[a] (%) | Success rate[b] (%) | Species | Description[c] | Location | Time after Treatment[d] | Notes | Reference |
|---|---|---|---|---|---|---|---|---|
| **Triclopyr BEE** | Diluted with diesel fuel, concentration NR[f] | "Nearly all" | White ash<br>Hard maple<br>American elm<br>Cherry | NR[f] | NR[f] | | | MacKasey *et al.* 1982 in Mallik *et al.* 1997[32] |
| **Glyphosate** | 5% in winter<br>10% in spring and Summer | 100%<br>100% | Hardwoods | NR[f] | NR[f] | NR[f] | "Glyphosate applied in winter required only a 5% solution";<br>"Triclopyr worked best after summer application"<br><br>The form of the active ingredient (salt, acid or ester) was unspecified. | Marrs 1985 in Mallik *et al.* 1997[32] |
| **Triclopyr** | NR[f] | NR[f] | | | | | | |
| **Triclopyr BEE (Garlon 4)** | 1 and 2% with diesel fuel | "Very effective" for fresh cut-stumps | Ash<br>Oak<br>Maple | NR[f] | NR[f] | NR[f] | | Wallace *et al.* 1984 in Mallik *et al.* 1997[32] |
| **Triclopyr TEA (Garlon 3A)** | 50–100% | "Effective control" | Tanoak<br>California black oak | NR[f] | NR[f] | NR[f] | "Spring application provided effective control" | Warren 1980 in Mallik *et al.* 1997[32] |
| **Glyphosate (Roundup)** | 5, 10, 15 and 20% solutions | See Note | Aspen | NR[f] | NR[f] | NR[f] | "Lower numbers of sprouts than the controls up to seven years post-treatment" | Whaley and Johnson 1992 in Mallik *et al.* 1997[32] |
| **Glyphosate (Roundup)** | NR[f] | "Excellent control in the first growing season" | Red maple<br>Yellow poplar<br>Sourwood<br>White oak<br>Swamp chestnut Oak | NR[f] | NR[f] | NR[f] | | Zedaker *et al.* 1987 in Mallik *et al.* 1997[32] |
| **Triclopyr TEA (Garlon 3A)** | NR[f] | | | NR[f] | NR[f] | NR[f] | | |

[a] Concentration of the formulated product. Percent of active ingredient varies by product.
[b] Success is defined as a lack of observable stump-based resprouting at the specified time from treatment, unless noted.
[c] Describes species as a whole, not individuals treated, unless noted otherwise. DBH = Diameter at breast height.
[d] "Time after Treatment" is the length of time between the application of herbicide and the observations made to determine success rate.
[e] Success was defined as >75% defoliation in this study.
[f] NR = Not Reported in the summary by Mallik *et al.*[32]

## *2.2 Assessing the Impacts of Chemicals on Humans*

The human toxicity sections of this report provide a summary of information on known pesticide hazards to humans. The goal of these sections in Chapters 3 and 4 is to summarize any available poisoning incident data and human epidemiological studies. More studies are available for the older, more widely used herbicide glyphosate. Less information is available for triclopyr, and almost no human data are available for the surfactants and dye.

The human toxicity sections for each chemical draw on the peer-reviewed scientific literature and a variety of pesticide poisoning incident surveillance systems (described in detail in Section 2.2.4 below).

High toxicity alone does not necessarily equal high risk. If there are few routes of exposure or if organisms are only exposed to very small quantities of the chemical, risk is generally anticipated to be low. Exceptions to this "dose-makes-the-poison" paradigm are the low-dose effects observed from exposures to certain endocrine-disrupting chemicals, discussed in Section 2.3.6 below. Endocrine disruption may occur at doses below those known to cause the frank toxicity that is typically evaluated in animal studies. These chemicals may be more toxic at very low doses than at moderate doses. Although information on endocrine disrupting potential is available for some pesticides in the peer-reviewed literature, EPA is only now beginning a large-scale endocrine disruptor screening program for pesticides.[33]

### 2.2.1 Overview of US EPA's Process for Assessing Risk to Humans

US EPA's methods for assessment of pesticide risks to humans rely primarily on hazard data obtained from laboratory animal studies. US EPA develops Reference Doses (RfDs) for pesticides from studies in which animals are exposed to a range of doses and observed for adverse effects. The highest dose at which no adverse effects are observed is called the No Observed Adverse Effect Level (NOAEL). The lowest dose at which adverse effects are observed is called the Lowest Observed Adverse Effect Level (LOAEL).

The RfD is calculated for humans by dividing the NOAEL by two uncertainty factors:
1) an interspecies uncertainty factor of 10 to account for the fact that humans are different from experimental animals, and 2) an intraspecies uncertainty factor of 10 to account for the fact that different humans respond differently to different chemicals. If only a LOAEL is obtained from an animal study (i.e., all doses tested caused an adverse effect) an additional uncertainty factor ranging from three to ten is also included. Both short-term (acute) and long-term (chronic) animal tests are conducted to evaluate the effects of a chemical on immediate systemic toxicity, carcinogenicity, developmental and reproductive toxicity, and neurotoxicity.
The hazard data from animal studies provide information on the types of adverse effects that the pesticide may cause at the doses evaluated. This hazard assessment is coupled with an exposure assessment based on anticipated uses of the pesticide to develop a complete picture of potential risks associated with pesticide use. Other data sources such as pesticide poisoning incidents and human epidemiological studies are valuable for determining potential effects of a pesticide on humans.

### 2.2.2 Routes and Sources of Exposure

Potential pesticide-related adverse health effects depend on the type of formulation, concentration, amount, route, and duration of exposure. This section provides a review of human exposure to pesticides and describes acute and chronic adverse health effects resulting from pesticide exposure.

Pesticides can enter the human body through the skin, eyes, ingestion and inhalation. The sources of pesticide exposure can be occupational, non-occupational and involuntary to the general population from ingestion, drift, and dermal exposure.

**Skin:** The skin is the largest organ in the body and the major route of absorption of pesticides. Children have more skin surface for their size, and this larger surface-to-volume ratio increases their absorption compared to adults. Children also have other metabolic and physiological differences that affect susceptibility to effects of chemicals at levels that may not be toxicologically significant in adults.[34, 35]

**Eyes:** Because blood vessels in the eye are close to the surface, pesticides can enter the bloodstream through the eye and cause poisoning, but this is rare. Most cases of eye injuries from pesticides are from direct contact, or from splashes and spills.

**Ingestion:** Accidental and suicidal ingestion are major routes of pesticide exposure. Pesticides can also be ingested via hand-to-mouth contact, eating contaminated food or drinking contaminated water. Pesticides that are swallowed are exposed to the digestive system that detoxifies many chemical substances.

**Inhalation:** Even though the respiratory tract is not a major route of pesticide entry into the body compared to the skin, absorption is almost 100 percent after entry into the deeper air passages of the lungs. The lungs are the major route of absorption of gaseous pesticides.

How deeply non-gaseous pesticides penetrate the upper airways and the lungs depends on particle size, breathing rate, and the amount of fresh air and ventilation. The smaller the particle, the greater the number of breaths per minute will be, and the less circulating fresh air, the greater the deposition will be. Inhalation exposure has the potential to cause more damage than ingestion at the same doses because the pesticide goes directly to the bloodstream.

Granules, dusts, and some powders are large enough to be trapped in the nose and upper air passages before they get into the lungs (see Table 2-3). Gas deposition depends on its solubility in lung tissue. Semivolatile compounds exist as both particles and gases simultaneously.

**Table 2-3: Respirable Particle Sizes**

| Size (microns) | Particles can reach |
|---|---|
| > 10 | upper air passages |
| 5–10 | central bronchial passages |
| 1–5 | peripheral bronchial passages |

**Occupational Exposure:** Workers with the highest exposure to pesticides are those who handle concentrated formulations, mixing and loading them into airplanes, tanks, sprayers, and other equipment or containers. Applicators of dilute sprays have less exposure. Most of these workers are in agriculture, lawn and turf management, highway rights-of-way, and forestry. Workers can also be exposed from drift (airborne movement away from the site of application). Other workers can be exposed during activities related to stocking, storage, and transport of pesticide products, or through spills, damaged pesticide containers, equipment maintenance, and janitorial work.

**Non-occupational Exposure:** Pesticide products in dilute and concentrated formulations are readily available over-the-counter and are widely used for home, lawn and garden, pet and personal use by the general public. Involuntary exposures to the general population can result from drift, entry into treated areas, eating contaminated food or drinking contaminated water.

### 2.2.3 Biomonitoring

Biomonitoring is the measurement of chemicals and their metabolites in body tissues and fluids. It is a direct measure of the amount absorbed into the body from all sources of exposure (skin, inhalation, ingestion, and ocular) at the time of sampling. It is not a measure of toxicity, but can provide an estimate of a dose from different exposure pathways.

Biomonitoring is useful for documenting exposure to pesticides, especially when absorption rates are low, or when there is no apparent illness or measurable effect on physiological responses. The most common bodily fluid measured is urine since it is easy to collect and does not require an invasive procedure such as drawing blood. Ideally, urine should be collected over a complete 24-hour period. Most specimens are “spot” samples, which are corrected for creatinine to account for urine volume differences over the course of the day.

### 2.2.4 Pesticide Illness Surveillance

Surveillance involves the systematic collection, analysis, and interpretation of health data. Existing pesticide surveillance programs collect information on acute (short-term) illness; there are no programs monitoring potential chronic (long-term) effects.

Current pesticide illness surveillance systems in place in the United States have limitations, and do not represent or reflect the true number of pesticide-related illnesses. A national system of reporting of pesticide illness does not exist, and California is the only state with a comprehensive mandatory reporting program.

**Underreporting**: Many individuals (perhaps most) with low to moderately severe pesticide-related illness do not seek medical care, or do not contact appropriate regulatory agencies. Those who do seek medical care may not be correctly diagnosed. Moreover, even those cases that are correctly diagnosed may not be reported to state surveillance systems.

**Lack of information:** The signs and symptoms of pesticide-related illness are not unique, and most doctors and health care providers know very little about pesticides. The information needed to document whether an illness is related to pesticides may not be collected in a timely fashion, or clinical tests may not be readily available.

Pesticide exposure may not even be considered or implicated until long after an incident has occurred, when it is too late to collect appropriate samples or obtain further information.

**Existing systems:** In spite of these problems and deficiencies, there are large amounts of useful data available from existing surveillance systems. If data are available from any of the following systems for the pesticides under review, they are included in the section for that pesticide.

**TESS:** The Toxic Exposure Surveillance System (TESS) is a program established by the American Association of Poison Control Centers in 1983. The program collects reports from about 85 percent of the poison control centers in the United States; about 90 percent of the reports are from home-based exposures. Four states do not have poison control centers and do not participate in TESS based surveillance (Maine, Mississippi, South Carolina, and Vermont).[36]

**SENSOR:** Another pesticide illness surveillance database is the Sentinel Event Notification System of Occupational Risk (SENSOR). It was developed in the 1980s as a collaborative project between the National Institute for Occupational Safety and Health (NIOSH) and health care providers in several states. Its purpose was three-fold:

- To improve health care providers' awareness and understanding of certain occupational disorders.
- To promote uniformity in case reporting.
- To pursue preventive interventions if warranted.

Pesticide poisoning was one of the seven disorders chosen for surveillance (the others were silicosis, occupational asthma, lead poisoning, carpal tunnel syndrome, and noise induced hearing loss).[37, 38]

Health departments in six states (California, Iowa, Michigan, New York, Texas, and Washington) receive NIOSH funding and technical support to bolster pesticide-related illness and injury surveillance. Six additional states are unfunded SENSOR-Pesticides partners and receive technical support from NIOSH (Arizona, Florida, Louisiana, New Mexico, North Carolina, and Oregon). Funding support for the SENSOR-pesticide program is also provided by the EPA.[39]

SENSOR incidents are classified into four severity categories: low, moderate, high and death.

- **Low severity:** illness or injury consists of health effects that may not require treatment, with minimal time (three days) lost from work or normal daily activities.
- **Moderate severity:** illness or injury consists of non-life-threatening health effects that generally receive treatment, and normal functioning returns without risk of disability. Time lost from work or activities is generally less than five days.

- **High severity:** illness or injury consists of life-threatening health effects that usually require hospitalization and may result in permanent disability. Considerable time (more than five days) is often lost from work or activities.

Potential pesticide-related illnesses are classified as "definite, probable, possible, or suspicious" by the health department reporting the case. The determination depends on the certainty of exposure, whether health effects consisted of signs observed by a health care professional versus symptoms reported by the poisoned subject, and the extent to which the health effects were consistent with the known toxicology of the implicated pesticide product.

**The California Program:** California's mandatory pesticide illness reporting system dates back to 1971, and is the most comprehensive reporting system in the country. Now known as 'The Pesticide Illness Surveillance Program (PISP), it is administered by the Worker Health and Safety Branch of the Department of Pesticide Regulation's (DPR), of the California Environmental Protection Agency (Cal-EPA).

The program is based on doctor's reports of pesticide illness, and illness reports submitted to the State workers' compensation system, which biases the program toward occupational exposures. People who are injured off the job, or who fail to seek medical care after pesticide exposures, are unlikely to be included in the system.

The local County Agricultural Commissioner (CAC—there are 56 CACs for California's 58 counties) investigates incidents and circumstances of exposure. Medical records and investigative findings are then evaluated by the DPR staff who categorize the relationship between pesticide exposure and illness or injury using the following criteria:

- **Definite:** Signs and symptoms exhibited by the victim would be expected to result from the reported exposure. Physical evidence (e.g., leaf samples or contaminated clothing) documents exposure and medical evidence (blood or allergy tests) demonstrates that the symptoms derive from the exposure. Since most cases are identified through the workers' compensation system *weeks or months after the incident*, reports by a competent observer, such as a physician, are accepted as evidence. (Emphasis added).
- **Probable:** Evidence that is more limited suggests a relationship between the pattern of exposure and the illness or injury, despite ambiguous or missing medical and/or physical evidence.
- **Possible:** Information may be ambiguous, although there is some correlation between the suspected pesticide and the illness or injury. For example, headaches, nausea and skin rashes could be related to sources other than pesticides.
- **Unlikely:** Signs and symptoms reported are not typical for suspected exposure, but the possibility of pesticide illness or injury cannot be ruled out.
- **Unrelated:** Evidence demonstrates the illness or injury was caused by factors other than pesticides.
- **Indirect:** The illness or injury is attributed to measures taken to avoid exposure, such as heat stress caused by labor in heavy protective clothing.

Portions of the data not subject to medical patient privacy laws are available to the public as annual summary reports and tables on DPR's website.[40]

### 2.2.5 Acute Effects of Pesticide Exposure

Acute effects are short-term effects that occur close in time to exposure, within a few minutes to a few hours. Local (topical) effects are those that affect only the surfaces contacted that come in contact with the pesticide, such as the eyes, skin, nose and throat. Under these circumstances, the chemicals do not enter the bloodstream or cause systemic illness.

Systemic poisoning occurs when a toxic chemical enters the bloodstream and is carried throughout the body, adversely affecting internal organs and body systems. In many cases of pesticide poisoning the most severe effects resulting in life-threatening illness and death are related to accidental or suicidal ingestions.

The U.S. Environmental Protection Agency (EPA) classifies pesticides into four categories based on acute toxicity in animals: Toxicity Class I (called Tox I) are the most toxic, Tox II are moderately toxic, Tox III are of low acute toxicity and Tox IV are the least acutely toxic. The EPA also estimates a lowest no observable adverse effect level (NOAEL) of pesticides in humans in milligrams of chemical per kilogram of body weight (mg/kg) per day. The daily oral exposure to humans, including sensitive subgroups such as children, that is not likely to cause non-cancer adverse effects during a lifetime is known as the reference dose (RfD).

The Occupational Safety and Health Administration (OSHA) sets a permissible exposure limit (PEL) for many chemicals.[41] The American Conference of Governmental Industrial Hygienists (ACGIH) sets limits for workplace exposure to hundreds of chemical substances and physical agents, including threshold limit values (TLV) in air.[42] Where available, OSHA PELS and ACGIH TLV limits are included in the specific chemical sections.

### 2.2.6 Chronic Health Effects of Pesticide Exposure

Chronic health effects are long-term effects that include cancer, reproductive problems, impaired development and neurological disease, among others. The EPA assesses the risk of human chronic health effects of pesticides based on animal data required to register a product. Although human health studies may be available, the US EPA does not always include such epidemiological data in the risk assessment process. There are no human data available for most pesticides.

A major constraint in assessing potential chronic health risks from pesticides is documenting exposure. Workers who directly handle pesticide formulations are at the highest risk, since they have the highest exposure and the longest duration of exposure. Home exposure from direct use of over-the-counter products is usually infrequent and not comparable to occupational exposures. Exposures to the general public from being in treated areas are typically low, especially when treatments are infrequent—annually or less.

#### *2.2.6.A Cancer*

Cancer potentially related to pesticide exposure develops years after exposure and can result from legal use that does not cause any apparent acute illness. In human studies, risk is

determined by comparing people with low, medium or high levels of exposure to unexposed controls. A dose-response, in which risk increases with increasing levels of exposure, strengthens any associations found. Little is known of the risk of chronic low-level, lifetime exposure.

It is uncommon for a single pesticide to be directly associated with a specific cancer, because people are exposed to multiple pesticides and other chemicals, and use patterns have changed over time. Pesticides might act synergistically, and cumulative exposures over time are difficult to document. If the type of cancer is rare or infrequent, or the number of people in an exposed group is small, an association with pesticide exposure may not be found, even if one exists.

Many pesticides are classified as possible or probable human carcinogens, based on animal data. In March 2005, EPA released its final *Guidelines for Carcinogen Risk Assessment* (EPA/630/P-03/001B), which replaces EPA's original cancer risk assessment guidelines (1986) and its interim final guidelines (1999).[43] Current US EPA pesticide cancer classifications are a mix of those used in the older and newer guidelines.

#### *2.2.6.B Reproductive Outcome*

Potential pesticide related reproductive outcome in humans involve maternal, paternal and fetal effects from exposures prior to conception, at the time of conception, and throughout a pregnancy, as well as effects on fecundity (fertility). Toxic effects on the fetus (fetotoxicity) include early fetal loss (spontaneous abortion), late fetal loss (stillbirth), intrauterine growth retardation (low birth weight), prematurity, birth defects, and neurodevelopmental effects. Paternally mediated effects are possible if exposure occurs prior to conception and the pesticide is excreted in the semen, since a complete spermatogenesis cycle takes just over two months.[44]

**Spontaneous abortion:** Fetal loss in the first 20 weeks of pregnancy (miscarriage) is notoriously difficult to study because it usually occurs before the woman knows she is pregnant, and most cases are not clinically recognized. Estimates are that up to 50% of all fertilized eggs die and are aborted spontaneously, as are about 10 percent of recognized pregnancies. A study using human chorionic gonadotropin (HCG) to document pregnancy found a 62 percent fetal loss prior to 12 weeks, of which most (92 percent) occurred without the knowledge of the mother.[45] A study of 152 conceptions using HCG to document pregnancy, found a 43 percent early fetal loss of which only 14 (9.2 percent) were clinically recognized; 50 (32.8 percent) were recognized only by HCG in the urine.[46]

Spontaneous abortion is higher in women over age 35, in those with certain diseases such as diabetes or thyroid problems, and women with a history of three or more prior miscarriages.[47]

Factors known to contribute to adverse maternal, paternal, and fetal outcome, regardless of a potential toxic exposure, include maternal and paternal age, alcohol use, smoking, drug use, nutritional status, and prior oral contraceptive use, among others.

**Fecundability:** Fecundability, a measure of fertility, is the number of months or menstrual periods it takes for a couple to conceive a child when not using birth control—also known as 'time to pregnancy'. A fecundability ratio (FR) is calculated by comparing time to pregnancy in couples exposed to pesticides compared to unexposed couples.

An FR of one means there is no difference between the exposed and non-exposed couples. A ratio greater than one means the exposed couples are more fertile (they got pregnant in a shorter period of time). A ratio less than one means the pesticide-exposed couples took longer to get pregnant. The lower the ratio, the less fertile (fecund) the couple.

**Birth Defects:** Birth defects, structural and anatomic malformations that occur during the first trimester of pregnancy in about three percent of live births (1 in 33) in the U.S., are the leading cause of infant mortality and childhood disease and disability. Birth defects do not include metabolic or genetic disease such as cystic fibrosis and sickle cell anemia, or functional problems without structural damage such as mental retardation and deafness. The most common types of birth defects in the US include heart defects, cleft lip and palate, Down syndrome, and neural tube defects. The cause for most birth defects is not known.

### 2.2.7 Epidemiology

Epidemiology is the study of diseases and their causes in human populations. Unlike clinical medicine, it does not involve diagnosing or determining disease in a particular individual. Epidemiology is based on comparisons of populations. For example, groups of people with cancer (‘cases’) are compared to people without cancer (‘controls’), or people with pesticide exposure (‘cases’) are compared to those without exposure (‘controls’).

The purpose of the studies is to determine if the people with cancer or other diseases (cases) are more likely to have exposure to pesticides than the people without cancer (controls). Alternatively, studies can find out if the people with pesticide exposure (cases) are more likely to have cancer or other diseases than people without pesticide exposure (controls). There are two basic kinds of studies, prospective and retrospective.

#### *2.2.7.A Prospective Studies*

The ideal type of study is prospective, in which a group of people (called a cohort) are followed over an extended period of time, often for years. Such studies provide the most meaningful data for risk assessment for three reasons.

1. Any adverse outcome is not present at the onset of the study.
2. Exposure can be better documented.
3. Events and exposures are recorded in real time and not based on past memories.

Prospective studies are much less common than retrospective studies because they are very expensive to conduct, and require a long period of time to produce results.

A very important prospective study of pesticide exposure is the Agricultural Health Study (AHS), conducted by the National Cancer Institute’s (NCI) Occupational Epidemiology Branch. It involves a cohort of 89,658 subjects — 52,395 farmer and 4,916 commercial applicators licensed to apply restricted use pesticides, and 32,347 spouses of farmer applicators.[48] Participants were recruited in Iowa and North Carolina from December 1993 through December 1997.[49] Findings from the study are included in the specific chemical sections as available.

#### *2.2.7.B Retrospective Studies*

Most human epidemiology involves case-control studies, which rely on experiences and exposures in the past. The major problem with retrospective studies is "recall bias" or differential memory, in which people who are ill (cases) are much more likely to remember specific exposures than healthy people (controls) are.

If pesticide exposure is being studied, the cases could be farmers who apply pesticides, farm workers who cultivate and harvest crops sprayed with pesticides, exterminators, pesticide factory workers, home and garden users, or people living in areas of high pesticide use.

If a condition is being studied, the cases could be groups of people with brain cancer, birth defects, asthma, Parkinson's disease, or other disease, and the controls those without the disease.

#### *2.2.7.C Risk Ratios*

Epidemiological study results are reported as risk ratios. Risk is the average probability that a disease will occur given a particular exposure. Risk ratios (RR), odds ratios (OR), or hazard ratios (HR) indicate whether people with a specific disease are ***more*** likely to be exposed (increased risk), ***equally*** likely to be exposed (no difference in risk), or ***less*** likely to be exposed (decreased risk) than the people without the disease.

> **More likely:** If the ratio is greater than one (> 1), those with pesticide exposure are more likely to have cancer, or those with cancer are more likely to have pesticide exposure — the risk is *increased*. A ratio of 1.4 means a 40 percent increase in risk; a ratio of 2.0 means a doubling of the risk, or a 200% increase. The higher the ratio, the greater the risk.
>
> **Equally likely:** If the ratio is equal to one (= 1) this means that those with pesticide exposure are no more likely to have cancer than those without exposure; or that those with cancer are no more likely to have pesticide exposure than those without cancer — there is *no difference* in risk.
>
> **Less likely:** If the ratio is less than one (< 1), it means that those with cancer are less likely to have pesticide exposure than those without cancer; or that those with pesticide exposure are less likely to have cancer than those without exposure—the risk is *decreased*. A ratio of 0.80 means a 20 percent decrease in risk; a ratio of 0.40 means a 60 percent decrease in risk. The smaller the ratio, the lower the risk.

#### *2.2.7.D Other Factors*

When studying humans, it is impossible to determine every factor (variable) that might influence the development of a disease. It is possible that a reported increase in risk is not from a particular exposure such as pesticides, but from something else, or a combination of the pesticide exposure and another variable. This could be a factor the researcher did not think of, or even ask about. Alternatively, it could be from a combination of exposures with unknown or unstudied factors.

The result also could have occurred by chance, and not be related to the exposure. When multiple exposures exist or comparisons are made, some effects could be found to be related to pesticides

by chance alone. Finding an increase in risk does *not* mean that a particular exposure *caused* the adverse health effects, only that there is a statistical association between an exposure and an illness.

#### *2.2.7.E Testing Statistical Significance*

There are methods to test whether or not an increase or decrease in risk found in a particular study is real (significant) or occurred by chance (not significant). The most common tests of statistical significance are the 'p' value, and confidence intervals.

**The 'p' value**: The 'p' value tests whether the findings could have occurred by chance, and by convention is usually set at five percent or less for statistical significance. This means the reported findings could have occurred by chance less than five percent of the time; or were unlikely to have occurred by chance 95 percent of the time. If the p value is more than five percent (> 0.05), then the effect is considered to have occurred by chance, and is unlikely to be related to a particular exposure.

The smaller the p value the more significant the findings. For example '$p \leq 0.01$' (less than or equal to point, zero, one) means that the effect could have occurred by chance less than one percent of the time or less, or is unlikely to have occurred by chance 99 percent of the time.

**Confidence intervals:** The confidence interval tests how close the risk ratio found in a study is to the 'true' or expected value. It is usually set at 95%, and written as $CI_{95\%}$ or 95% CI. This means that if the same study were performed 100 times, the results of the study would be within the reported confidence interval 95 times.

The lower number of the confidence interval is written first. If the lower number is less than one (< 1), then the increase in risk is considered "not significant," and could have occurred by chance. If the lower number of the interval is greater than one (>1) then the increase in risk is considered 'significant'. If the lower number is equal to one (=1), the risk is considered to be borderline significant.

If the number of cases is small, the confidence interval can be very wide, and the less confidence there is in the findings. The larger the number of people in a study (sample size), the narrower the confidence interval, and the more robust the findings.

**Statistical Power:** When analyzing significance it is important to consider statistical power. Power can be defined as the probability that the test will find a statistically significant result given that there is a real effect. The magnitude of the effect and the number of experimental replicates are critical to statistical power.

For example, it is difficult to say confidently that a very small effect observed in rats dosed with a pesticide is statistically significant without multiple data points or studies that repeatedly show the same small effect. In contrast, it is easier to be confident that an observed toxic effect is related to the pesticide exposure if the effect is substantial or occurs in many animals.

## *2.3 Assessing Impacts of Chemicals on Animals and Other Organisms*

The ecotoxicity sections of this report provide a summary of known pesticide hazards to a variety of representative aquatic and terrestrial species. The goal of these sections for glyphosate and triclopyr in Chapters 3 and 4 is to summarize available toxicity data for representative aquatic and terrestrial species. Toxicity endpoints from the available studies are compared to estimated environmental exposures to determine wildlife risks for the selected herbicides. The ecotoxicity sections for each chemical draw heavily from the United States Forest Service's Risk Assessments, EPA's Re-registration Decisions, Effects Determinations or Registration Review Documents, and the EPA Ecotox databases (termed "Terretox" for terrestrial toxicity studies and "AQUIRE" for aquatic toxicity, as well as EPA's database of toxicity studies submitted by registrants[50]). A literature search of peer-reviewed publications was also conducted. For glyphosate, which has been used extensively since 1974, this report summarizes the most relevant literature, but does not provide an evaluation of every available study. For triclopyr, this report provides a comprehensive summary of peer-reviewed studies that are relevant to the UCSF Mount Sutro project.

### 2.3.1 Overview of the Process for Assessing Risks to Animals and Other Organisms

As part of US EPA's process for registering a chemical, toxicity studies must be performed by the manufacturer to quantify the chemical's potential risk to humans (using laboratory animals as a surrogate) and terrestrial and aquatic wildlife. Studies required by US EPA are to be conducted according to the US EPA guidelines,[51] but are not subject to peer review outside of US EPA. Surrogate species (mallard duck, Norway rat, honeybee, etc.) are chosen to represent a broad set of animal taxa (birds, mammals, insects, etc.) that might be exposed to the chemical in the environment. For mammals, studies on acute and chronic toxicity are required, including cancer, developmental and reproductive effects. Acute toxicity tests are required for birds, fish and honeybees. Studies on reproductive toxicity in birds may be required for some pesticides, but generally, chronic and sub-chronic effects are not evaluated for wildlife in EPA's risk assessments. EPA does not require amphibian toxicity studies; however, many ecologists are now evaluating the potential of pesticides to contribute to observed declines in amphibian populations; these results are available from the peer-reviewed literature.[52]

Since the species within a taxa group vary in their responses to chemical exposure, using information from a surrogate species to predict species-specific toxicity can be inaccurate. Some species are clearly at greater risk because of their habitats or behaviors that predispose them to higher exposures. However, for some chemicals (e.g., glyphosate) the doses at which effects are observed are remarkably similar across taxa when corrected for the organism's size and metabolism.[53]

More studies are available for older, more widely used pesticides, in part due to contributions from academic and agency scientists. The focus of these studies frequently goes beyond mere acute toxicity, with evaluation of sub-lethal effects such as effects on reproductive success, behavior, and predator avoidance, among others. These effects typically occur at doses lower than one that is lethal to the organism and may reasonably be anticipated to be encountered in the organism's environment. In this report, low-dose, sub-lethal effects are reviewed where they are available.

### 2.3.2 Routes of Exposure

Wildlife on Mount Sutro can encounter pesticides at the application site or in surrounding areas contaminated by airborne spray drift or runoff of contaminated water. Chemical exposure routes are divided into three pathways: oral, dermal, and inhalation. In terrestrial organisms, chemicals can be ingested orally through eating contaminated food, drinking contaminated water, grooming, and ingesting residues from contaminated surfaces. Herbivores ingest pesticide residues from plants, and if the chemical is persistent, can store it in their bodies. Omnivores and carnivores can ingest pesticides by eating prey that contain pesticides in their bodies or on their skin. In some cases, predators at the top of the food chain (including humans) can be exposed to high concentrations of persistent pesticides through bioaccumulation of the chemical in prey. None of the pesticides evaluated in this risk assessment bioaccumulate substantially. Oral exposure to a chemical may also occur through contact with a treated surface. For example, a bird building a nest from leaf litter contaminated by drips from applicator equipment might directly ingest the chemical from transporting nest-building materials in its mouth. This same bird may also ingest the chemical when preening contaminated feathers.

Wildlife can also absorb chemicals through the skin. This exposure route is especially important to animals with permeable skin, or animals that lack fur or feathers. Frogs are a good example; contamination of the water in which they live guarantees dermal exposure.

Exposure through inhalation of a chemical requires that the chemical be airborne as either a gas or an aerosol. Aerosols can be present in the air directly following chemical application before spray droplets have settled. Volatile pesticides can be present in gaseous form near the application site for several days to several weeks after the application.[54] Neither glyphosate nor triclopyr are considered volatile, based on their vapor pressure (defined in Section 2.4.1).

Aquatic animals are exposed through ingestion of contaminated food and through skin and/or gill contact with contaminated water. Toxicities are expressed in terms of a concentration of the chemical in water instead of a dose to account for this multi-pathway exposure.

### 2.3.3 Definitions of Terms Used

Ecotoxicity information is expressed as the effect(s) observed at a particular concentration, the "endpoint." These endpoints represent Levels of Concern (LOC) and are determined by exposing an organism to a known dose of pesticide for a specified length of time (the study time) and noting the dose that causes a measurable effect (death, reduction in growth, hormonal changes, etc.) in a given percentage of the target organisms. Typical endpoints used in ecotoxicity studies include:

- **$LD_{50}$:** An $LD_{50}$ is the Lethal Dose of the pesticide in milligram (mg) of pesticide per kilogram (kg) of body weight that kills 50% of the test organisms within the stated study time. More generally, this number can be expressed as $LD_x$, where *x* is the percent of the study population that is killed at a particular dose. For bees, the $LD_{50}$ is given in micrograms (μg) per bee. Exposure is tested both as a dermal dose on the body of the bee or in food.

- **$LC_{50}$:** For aquatic species, an $LC_{50}$ is defined as the Lethal Concentration of a chemical in milligrams per liter of aqueous solution that kills 50% of the test organisms within the stated study time. As with the $LD_{50}$, the LC endpoint can be expressed as $LC_x$, where *x* is the percent of individuals that die. For terrestrial organisms, the $LC_{50}$ is the concentration of a chemical in food or water that the organism consumes.
- **$EC_{50}$:** An $EC_{50}$ is the Effective Concentration of the pesticide in mg/L that produces a specific measurable effect in 50% of the test organisms within the stated study time. This metric is primarily used for aquatic species.
- **LOEL (LOAEL):** A LOEL (Lowest Observed Effect Level) or LOAEL (Lowest Observed Adverse Effect Level) is the lowest chemical dose at which a given effect is observed. Effects are variable and include such endpoints as weight loss, changes in blood chemistry, impaired reproduction or development, formation of tumors, etc.
- **NOEL (NOAEL):** A NOEL (No Observed Effect Level) or NOAEL (No Observed Adverse Effect Level) is the dose at which no effects (or adverse effects, with the definition "adverse" determined by the US EPA) are observed in comparison to the control group.

Acute toxicity studies, which comprise most of the available ecotoxicity data, have short study times designed for monitoring an organism's immediate response to a chemical. Often mortality is the observed effect and is reported as an $LD_{50}$, or $LC_{50}$. Acute toxicity studies typically do not measure sublethal adverse effects (such as reduced reproductive fitness, weight loss, decreased population abundance, etc.). However, sublethal effects are common and may lower a species' fitness or survival. Typically, sublethal effects are related to long-term, non-acute exposure, but can also result from one-time high doses. Results from sublethal studies are reported as an $EC_{50}$, NOEL or LOEL. Doses and concentrations for sub-acute effects can be considerably different (usually lower) than acute toxicity endpoints, but may still have a substantial impact on species survival. Summary tables of the doses or environmental concentrations associated with both morbidity and mortality for each chemical are presented in Appendices D and E.

US EPA defines a Level of Concern (LOC) based on the Risk Quotient (RQ) determined by dividing the estimated environmental concentration by a toxicity reference value such as an $LD_{50}$, $LC_{50}$, NOAEL, or NOAEC. The preferred endpoint to use in an evaluation of potential ecotoxicological risk is a NOAEL or NOAEC. However, NOAELs or NOAECs are not always available for every taxa group of concern. For studies in which only an $LD_{50}$ or $LC_{50}$ is available, US EPA defines the LOC for endangered birds and mammals as exposure equal to one-tenth of the $LD_{50}$ or $LC_{50}$; for aquatic animals and terrestrial invertebrates, the LOC is defined as exposure equal to one-twentieth of the $LD_{50}$ or $LC_{50}$.[55] We conducted the Mount Sutro risk assessment using the endangered species LOC values. The result is a conservative estimate of risk associated with the project.

Typical variables that influence a given toxicological endpoint are:

- The formulation of the product (*e.g.*, active ingredient versus formulated product, including surfactants and other ingredients).
- The temperature of the organism's environment.

- The dissolved minerals and pH in aquatic environments. For example, glyphosate dissolved in "soft" water, is more toxic than glyphosate in "hard", mineral-rich water, because $Ca^{2+}$ and $Mg^{2+}$ ions found in hard water bind to glyphosate, reducing its toxicity.
- The age of the organisms (*e.g.*, juveniles versus adults).
- The exposure route (*e.g.*, orally administered capsules, dermal exposure, mixing the chemical with food, etc.).
- The timing or frequency of exposure (*e.g.*, continuous exposure for three weeks versus twice daily for two weeks).

The study variables mentioned above are important details of any ecological toxicity report. Unfortunately, they are not always included in EPA's Ecotox database or in the USFS risk assessment. In some cases, the original reference paper was available for clarification but often it was not. Some of the studies reported in Ecotox or USFS reports were conducted by the pesticide manufacturer as part of the chemical's initial registration data package and are not publicly available for review.

For pesticides formulated as salts or esters of carboxylic acids (organic acids characterized by the presence of a carboxyl, or -C(=O)OH, group), $LD_{50}$, $LC_{50}$, LOEL and NOEL values are reported in carboxylic acid equivalents (a.e.) whenever possible. Glyphosate and triclopyr fall in this category. When these active ingredients (a.i.) are dissolved in water, they rapidly dissociate (salts of glyphosate) or hydrolyze (triclopyr butoxyethyl ester) to form the carboxylic acid equivalent. The ratio of acid equivalent to active ingredient is the ratio of the molecular weight of the acid form of the compound to that of the active ingredient. For glyphosate and triclopyr, the molecular weights of the pesticides and their salts and/or esters, the ratio of a.i. to a.e. is approximately 3:4. The precise value of this ratio is used in all calculations in order to compare concentrations and toxicities in terms of the acid equivalent.

### 2.3.4 Wildlife Toxicity Reference Tables

A toxicity study provides a dose or concentration at which an adverse effect is observed. This number alone is not sufficient to determine how toxic a particular substance is compared to other substances. Reference tables provide context for judging the relative acute toxicity of a particular chemical and have been developed for most taxa groups. The tables below divide acute endpoint values into toxicity ranges: not acutely toxic, slightly toxic, moderately toxic, highly toxic, and very highly toxic (see Tables 2-4 through 2-7 below). Reference tables have not been developed for sublethal effects.

Mammalian acute toxicity is typically obtained from laboratory animal studies and is expressed as an $LD_{50}$ in milligrams of chemical per kilogram of body weight of the test animal (Table 2-4).

**Table 2-4: Reference Toxicity Values for Mammals**

| Toxicity Category | $LD_{50}$ (mg/kg) |
|---|---|
| Very highly toxic | < 5 |
| Highly toxic | > 5–50 |
| Moderately toxic | > 50–500 |
| Slightly toxic | > 500–2,000 |
| Not acutely toxic | > 2,000 |

*Data source:* Reference 56.

For birds, acute toxicity is typically expressed as either an $LD_{50}$ in milligrams of chemical per kilogram of body weight (Table 2-5) or as an $LC_{50}$ representing the concentration of the chemical in food in milligrams of chemical per kilogram of food (Table 2-6).

**Table 2-5: Reference Toxicity Values for Birds: Dose per Unit Body Weight**

| Toxicity Category | $LD_{50}$ (mg/kg) |
|---|---|
| Very highly toxic | < 10 |
| Highly toxic | > 10-50 |
| Moderately toxic | > 50–500 |
| Slightly toxic | > 500–2,000 |
| Not acutely toxic | > 2,000 |

*Data source:* Reference 57.

**Table 2-6: Reference Toxicity Values for Birds: Concentration in Food**

| Toxicity Category | $LC_{50}$ (mg/kg) |
|---|---|
| Very highly toxic | < 50 |
| Highly toxic | > 50-500 |
| Moderately toxic | > 500–1,000 |
| Slightly toxic | > 1,000–5,000 |
| Not acutely toxic | > 5,000 |

*Data source:* Reference 57.

For aquatic organisms, reference toxicity values are given as a concentration in milligrams of chemical per liter of water (Table 2-7). In dilute aqueous solution at 25°C, this unit is equivalent to parts per million (ppm) or milligrams of chemical per kilogram of water.

**Table 2-7: Reference Toxicity Values for Amphibians, Fish, and Aquatic Invertebrates**

| Toxicity Category | $LC_{50}$ (mg/L) |
|---|---|
| Very highly toxic | < 0.1 |
| Highly toxic | >0.1–1 |
| Moderately toxic | >1–10 |
| Slightly toxic | >10–100 |
| Not acutely toxic | > 100 |

*Data source:* Reference 57.

The reference values in the tables above contextualize the toxicity of a given endpoint. In the exposure assessment and risk characterization, another reference value is used—a Toxicity Reference Value, or TRV—to establish the concentration or dose of a particular chemical that is anticipated to be protective of a specific taxa of organisms. Use of TRVs is discussed in greater detail in Section 2.5 and in the ecotoxicity sections for each chemical.

### 2.3.5 Indirect Effects of Herbicide Applications

In addition to their direct toxic effects on wildlife, herbicides can affect wildlife indirectly, where adverse effects occur through changes to habitat, reduction in food supply, or other mechanisms that are not a direct result of chemical toxicity. Numerous examples are given in the USFS risk assessment for glyphosate.[12] For example, a bird that survives the "direct effect" of herbicide toxicity may still die due to the "indirect effect" of lost food killed by the herbicide. In this example, the herbicide alters the food chain, restructuring the trophic interaction between the bird and its food supply. In an empirical example of indirect effects, Linz *et al.* 1995[58] found that glyphosate spraying of cattails affected the behavior of wetland blackbirds that utilize cattails for food and shelter. The results suggest that sprayed cattails provided less cover for blackbirds, reducing the number of roosting birds and causing a reduction in blackbird damage to nearby sunflower crops. The USFS 2011 report for glyphosate discusses multiple studies on altered trophic interactions in moose,[59] small mammals,[60a–h] birds,[61a–h] carabid beetles,[62a–b] various other invertebrates,[63a–c] and livestock.[64] Because such studies are difficult to perform and often yield equivocal results, the UCSF Mount Sutro risk assessment focuses only on direct effects of chemical exposure.

Invasive vegetation also alters trophic interactions, as non-native plants often do not provide sufficient food or habitat for native species. Reducing the populations of invasive plants will allow repopulation of the area by native plants that provide more food and shelter for native animal species.

### 2.3.6 Endocrine Disruption

Chemically induced endocrine disruption is a new area of research that current toxicology tests do not address. The endocrine system is composed of glands that secrete hormones directly into the circulatory system, including the ovaries and testes, the thyroid, parathyroid, adrenals, pituitary, and pancreas. Small changes in hormone levels are known to affect reproduction, neurological development, sexual development, metabolic processes, and mood, and may have other effects. Hormones play a crucial role in guiding normal cell differentiation in early life forms, and exposure to endocrine disrupting substances in the egg or in the womb can alter the

normal process of development. Mature animals can also be affected, but the developing organism is especially vulnerable. Exposure at this sensitive time may cause effects that are not evident until later in life, such as effects on learning ability, behavior, reproduction and increased susceptibility to cancer and other diseases.[65]

The toxicologists' mantra of "The dose makes the poison" does not necessarily hold true in the domain of endocrine effects.[66] Endocrine disrupting substances have effects at very low, potentially environmentally relevant, doses far below those used in typical toxicology studies. These effects often disappear at higher doses that may trigger an organism's chemical detoxification mechanisms and/or inhibition pathways. Unfortunately, to date little testing has been done specifically for endocrine disrupting effects.

Substantial laboratory and field evidence exists demonstrating that certain chemicals can affect the endocrine systems of animals. The European Union has published a list of chemicals for which some evidence exists for endocrine disruption in either government or peer-reviewed literature.[67] EPA notes that "compelling evidence shows that endocrine systems of certain fish and wildlife have been affected by chemical contaminants, resulting in developmental and reproductive problems."[68]

In 1996, Congress charged the US EPA with the task of screening pesticides for endocrine-disrupting potential.[69] The goal is to have a rapid assay that can quickly screen large numbers of chemicals with limited use of animal testing. To date, EPA has developed a number of screening assays and has validated most of the testing protocols.[70] In June 2007, the EPA published a draft list of initial pesticides to be screened,[71] as well as policies and procedures to be implemented in the Endocrine Disruptor Screening Program.[72] The finalized list of pesticides to be screened and the procedures for conducting the screening were published by EPA in April 2009,[33] and EPA sent out test orders to manufacturers during the summer of 2009. EPA issued test orders for a second set of chemicals in November 2010.[73] Testing will take approximately two years to complete, and results will be reviewed by EPA's Scientific Advisory Panel before EPA decides how to utilize these results in its risk assessment process.

The National Toxicology Program (NTP) is assisting EPA with developing method validation procedures for the *in vitro* estrogen receptor and androgen receptor binding and transcriptional activation assays.[74] The method validation procedures were published in 2002 and updated in 2006,[75] and will be used to evaluate the pesticides on EPA's list.

There is no evidence suggesting that, at low doses, any of the pesticide active ingredients, identified "inert" ingredients, or surfactants being considered for use by UCSF for the Mount Sutro project are endocrine disruptors. Some recent *in vitro* studies show endocrine effects of Roundup (a formulated product containing a toxic "inert" ingredient) at moderate concentrations and glyphosate at very high concentrations; however, this scenario is not reflective of any exposure scenario that would be encountered from normal herbicide use (see Chapter 3, Section 3.3.1.D). To avoid potential endocrine and other effects from unidentified "inert" ingredients, UCSF selected Aquamaster, which contains no surfactants—only glyphosate and water, as the glyphosate-containing product proposed for use, to be used with Competitor, a low-toxicity surfactant (see Chapter 5 for a review of its toxicity). Garlon 4 Ultra, the other herbicide selected

by UCSF, does contain unknown "inert" ingredients, leaving some unknowns in the risk assessment. It is worth noting that no definitive testing of the sort that US EPA is currently in the process of conducting has been done to confirm the endocrine-disrupting status of any of the pesticide active ingredients, surfactants, or mixtures of these ingredients.

## *2.4 Assessing the Fate of Chemicals in the Environment*

Once released into the environment, pesticides are subject to a number of processes that transport them away from the application site or degrade them into smaller molecules. Specifically, pesticides are transported off-site by water and air and degraded or inactivated by microbial and chemical reactions. Understanding these processes is critical for answering the following questions: (1) Are streams likely to be contaminated by herbicide use? (2) Are Mount Sutro visitors likely to be exposed to herbicides by picnicking or hiking near an application site? (3) Will wildlife be exposed to pesticides by eating contaminated vegetation?

This section provides essential background information on these processes and the calculations used to estimate chemical concentrations and lifetime in the environment.

### 2.4.1 How Physical Properties Affect Environmental Fate

The ability of a chemical to move through or degrade in the environment is governed by a number of chemical-specific physical properties. These include water solubility, half-life, vapor pressure, acid equilibrium constant, and distribution coefficients that provide a measure of chemical preference for a particular medium. The most important partition coefficients are: $K_{oc}$, distribution between water and soil; $K_{ow}$, distribution between water and a non-polar solvent; and $K_H$, distribution between water and air. These parameters are defined in more detail below.

**Water solubility:** Water solubility is a measure of how much of a chemical will dissolve in water and is expressed as the maximum mass of chemical that will dissolve in one liter of water. Typical concentration units are mg per liter (mg/L), equivalent to parts per million (ppm) in dilute aqueous solution at 25°C; or micrograms per liter (μg/L), equivalent to parts per billion (ppb) in dilute aqueous solution. The larger this number is, the more water-soluble the chemical, and the more likely it is to be transported through the environment in dissolved form in runoff or irrigation water. The state of California uses a water solubility of at least 3 mg/L as a cutoff value for designating pesticides likely to be mobile enough to leach into groundwater.[76]

**Half-life:** The persistence of a chemical in the environment is measured by its half-life, or time required for half of the chemical to be degraded through various chemical and biological processes. Half-lives can be expressed as hours, days, weeks, months or years and can be measured for specific degradation conditions (hydrolysis half-life, aerobic half-life, and anaerobic half-life are a few examples). A time equal to five half-lives corresponds to the degradation of 97% of the chemical. Half-lives can vary substantially, depending on temperature, pH, presence or absence of water, presence or absence of soil microbes, and/or exposure to sunlight and oxygen. The half-life is therefore better expressed as a range to represent the minimum and maximum values observed under different conditions. The state of California uses the following half-lives as a guide for designating pesticides likely to be persistent enough to leach into groundwater: Aerobic half-life: >610 days; anaerobic half-life: >9 days; hydrolysis half-life: >14 days.[76]

When evaluating the persistence of a chemical in the environment, there are two useful half-lives to consider: 1) the chemical half-life, which represents only processes by which the chemical is degraded, and 2) the field dissipation half-life, which accounts not only for degradation, but also for transport of the chemical away from the application site by wind, water, and volatilization.

**Vapor pressure:** The vapor pressure of a chemical is a measure of how readily it evaporates at a given temperature. The vapor pressure is a good predictor of which pesticides might be prone to evaporate from leaf and soil surfaces and move off-site in gas form after application. More formally, vapor pressure is defined as the pressure exerted by the pure substance in a closed system at equilibrium. Vapor pressure varies with temperature, increasing as the temperature increases and decreasing as the temperature decreases. In this document, vapor pressures are expressed in units of millimeters of mercury (mm Hg), measured at temperatures between 20 and 25°C. Pesticides with vapor pressures greater than $10^{-6}$ mm Hg can readily volatilize and drift off-site. Pesticides with vapor pressures less than $10^{-6}$ mm Hg do not volatilize substantially at normal temperatures. Higher temperatures, such as those encountered when herbicide-treated materials are burned, will cause even pesticides with low vapor pressures to volatilize.

**$K_d$ and $K_{oc}$—Soil distribution coefficient:** $K_d$ is a measure of the tendency of a chemical to bind to soils and is a function of the soil pH, clay content, mineral content and organic matter content. Because most pesticides tend to bind strongly to organic matter in the soil, the organic matter content predominates for most pesticides. The value of $K_d$ is determined by adding a chemical to an aqueous solution containing soil and measuring the amount of chemical remaining in solution. More formally, $K_d$ is expressed as the ratio of the mass of the chemical adsorbed to the soil per unit weight of soil (e.g., µg chemical adsorbed/g soil) to the concentration of the chemical in solution (e.g., µg/L) at equilibrium, and has units of volume per mass. The distribution constant $K_{oc}$ corrects the measured $K_d$ values for soil organic carbon content and is simply $K_d$ times the fraction of organic carbon in the soil. $K_{oc}$ values can vary substantially, depending on soil type, soil pH, the acid-base properties of the pesticide and the type of organic matter in the soil.[77] The state of California uses a $K_{oc}$ of 1,900 mL/g as a cutoff value for designating pesticides likely to be mobile enough in soils to leach into groundwater.[76]

**$K_{ow}$—Octanol-water partition coefficient:** The octanol-water partition coefficient, $K_{ow}$, is a measure of how a chemical distributes between two immiscible solvents—water (a polar solvent) and octanol (a relatively non-polar solvent). $K_{ow}$ is formally defined as the ratio of the concentration of pesticide in the octanol layer to the concentration of the pesticide in the water layer at equilibrium. Because it is a ratio of concentrations, the number is unitless. The value is dependent on temperature. The $K_{ow}$ value provides information on the polarity of the pesticide and is often used as a model for how the pesticide may be distributed in the body, e.g. blood vs. fat tissue. Pesticides with a long half-life and high $K_{ow}$ have been shown to bioaccumulate in the food chain in fatty tissues.

**$K_H$—Henry's Law constant:** The Henry's Law constant $K_H$ is a measure of how a chemical distributes between water and air at equilibrium, alternatively described as the tendency for a substance dissolved in water to escape to the air. Formally, $K_H$ is the pressure of a gas over a solution (in atmospheres) divided by the concentration of the chemical dissolved in solution (in

mol/L), which gives a constant with units of atm L/mol. Various other units are also used. A large value of $K_H$ means that the chemical has a strong tendency to escape from solution as a gas. A small $K_H$ value means that the chemical has a greater tendency to remain dissolved in solution.

**$K_a$—Acid dissociation constant:** The acid dissociation constant $K_a$ is the ratio of the dissociated components of a weak acid to the parent acid. Weak acids have small $K_a$ values, indicating that the acid is only partially dissociated, resulting in a relatively low concentration of $H_3O^+$ in a solution of the acid and a pH between 2 and 7. Strong acids have large $K_a$ values, indicating that dissociation is extensive and the concentration of $H_3O^+$ is large, producing a solution with a pH below 2. Many pesticides are weak acids.

All of these constants—$K_{oc}$, $K_{ow}$, $K_H$ and $K_a$—are equilibrium constants, which means that they can only accurately predict environmental concentrations when a system is at equilibrium. It is important to note that ecosystems are rarely at equilibrium. Still, these parameters remain useful predictors, since the direction of the shift in equilibrium can be predicted from environmental concentrations and the equilibrium constant.

### 2.4.2 Fate and Transport Processes

Pesticides can be transported away from the application site by water, air and soil movement. They can also be degraded by chemical or biological processes.

Water transports pesticides off-site by leaching of dissolved pesticides through soil to groundwater, runoff of dissolved pesticides to surface water, and by surface runoff of soil-bound pesticides.

**Leaching to groundwater:** Pesticides can dissolve in water and percolate through the soil, sometimes traveling as far as the water table. Pesticides most prone to this process have high water solubility, low ability to adsorb to soils, and long half-lives. Even pesticides that do not have these characteristics may still contaminate groundwater by traveling through rocky or fractured soils that provide a direct pathway to groundwater. High pesticide application rates and heavy rains will enhance transport to groundwater. Once in groundwater, pesticides are not exposed to sunlight or microbes, and typically degrade much more slowly than in soils or surface waters.

**Surface runoff of dissolved and adsorbed pesticides:** During heavy rains or high irrigation flows, pesticides can be dissolved and transported in runoff water. If the runoff event has sufficient volume and energy to carry sediment particles, even pesticides that are not particularly water-soluble can still be transported in the flow adsorbed to sediment and deposited in a new location.

Pesticides may also be transported off-site through the air, by spray drift during the application and/or volatilization drift that occurs both during and after the application.

**Spray drift:** Spray drift occurs during and for a few hours after a pesticide spray application. Fine droplets or dust particles created by spray equipment can be carried off-site by prevailing winds. Spray drift of herbicides can affect non-target plants, animals, and humans

near an application site at the time of the application. Both dermal and inhalation exposure are possible.

**Volatilization drift:** Volatilization drift occurs primarily with pesticides with vapor pressures greater than $10^{-6}$ mm of Hg. Higher vapor pressure and temperature lead to greater volatilization and subsequent wind transport. None of the herbicides or surfactants selected for potential use in the Mount Sutro project is highly volatile, so volatilization drift is unlikely in significant quantities.

**Wind erosion:** Transport of herbicides on dust particles can occur through wind erosion of dry and exposed soils. Depending on climate and soil type, annual wind-driven, agricultural soil losses have been estimated to range from 2–6.5 metric tons/ha.[22] Deposition of herbicide-contaminated soils can damage non-target plants and contaminate waterways far from the original application site.

Most pesticides are also degraded in the environment by microbial activity, photolysis, hydrolysis and other chemical reactions.

**Microbial activity:** Soil microbes—bacteria and fungi—metabolize most chemicals, using them as a source of organic carbon. Some microbes have even been observed to adapt to applications of herbicides by increasing the rate at which they metabolize that particular chemical. Both anaerobic and aerobic microbes contribute to pesticide degradation, although at different rates.

**Photolysis:** Sunlight, particularly in combination with oxygen in the air, can break chemical bonds and degrade pesticides in air, water and soil.

**Hydrolysis and other chemical reactions:** Pesticides can also be degraded through reaction with water (hydrolysis) or other substances in the environment. Some chemical reactions do not necessarily degrade the chemical structure, but may result in the formation of a new molecule or complex that changes the reactivity of the parent pesticide. An example of this is the complexation of glyphosate to clay soils, which decreases the bioavailability and the toxicity of this herbicide.

## *2.5 Exposure Assessment and Risk Characterization*

Exposure assessment involves estimation of exposures through all available routes, including drinking water, dermal contact, inhalation, and ingestion of contaminated food sources. A number of computer models have been developed to facilitate exposure analysis. The accuracy of the predictions obtained through modeling can be quite good if parameters used in the model are appropriate to the particular location and/or if model assumptions are correct. In all cases, it is important for models to be validated using measured exposure data, as Syracuse Environmental Research Associates (SERA) did when developing the USFS worksheets for glyphosate and triclopyr risk assessment used for the Mount Sutro project.[22] It is important to note that the risk calculations provide conservative estimates of Central, Upper and Lower exposures. In addition, most of the high-exposure scenarios are from accidental spills that can be prevented with sufficient care and attention by applicators.

It is useful here to distinguish between exposure (the amount of chemical an organism has encountered in the environment through oral, dermal or inhalation routes) and dose (the amount

of chemical an organism has absorbed into the body). For terrestrial animals, the USFS/SERA worksheets provide an estimate of absorbed doses in mg/kg of body weight; for aquatic species, they provide anticipated environmental concentrations in water bodies in mg/L, which is equivalent to exposure. The term "exposure" is used in this risk assessment as a general term that encompasses both exposure and dose, except where it is necessary to distinguish between absorbed dose and the environmental concentration.

The exposure analysis is divided into four broad categories: workers, the general public, terrestrial animals, and aquatic organisms. The exposure estimates are calculated in the same units as toxicity reference values (TRVs). For humans, the TRV is equivalent to US EPA's reference dose (RfD) in mg/kg-day. For wildlife, the TRV is a NOAEL in mg/kg day or NOAEC in mg/L or equivalent. Sometimes NOAEC/Ls are not available for wildlife, and $LC/D_{50}$ values are used instead as the basis for a TRV. Using US EPA's adjustments for LOC values to protect endangered species, uncertainty factors are applied to adjust the $LC/D_{50}$ so that it is equivalent to a NOAEC/L.[55] In this report, mammalian and bird $LC/D_{50}$ values were divided by a factor of 10 to obtain an estimated NOAEC/L; $LC/D_{50}$ values for aquatic species and terrestrial invertebrates were divided by a factor of 20.

To evaluate risk, exposure estimates are compared to TRVs to obtain a hazard quotient (HQ)—or the ratio of the estimated dose or concentration to the TRV. Wildlife hazard quotients above one suggest that a species or taxa is likely to encounter environmental concentrations/doses that may pose a risk to the species. Unlike human RfDs, the wildlife TRVs contain no uncertainty factors for different sensitivities between individuals or between the target organism and surrogate species (*e.g.* rabbits, dogs, and rats are used to represent deer and raccoons).

Hazard quotients between 0.1 and 1.0 indicate that there may be particularly sensitive individuals or species that may be affected. Very low hazard quotients indicate low levels of risk for the effects that have been studied and are represented by the TRVs. In this document, hazard quotients less than one are reported as a percent of the TRV; HQs greater than one are reported as a multiplier of the TRV, e.g. "the HQ was 2.4 times the TRV."

Water contamination estimates are developed for several acute spill scenarios, as well as peak runoff and long-term runoff (defined in Section 2.5.2 that might result in chronic exposure. These concentration estimates are used to estimate exposures from consuming contaminated water, for birds and mammals, and for living in contaminated water for aquatic animals and plants. Aquatic exposure scenarios include short-term accidental spills and peak runoff from treated sites and are designed to provide a conservative estimate of worst-case conditions.

Human exposure estimates are developed for both workers and the general public. Worker exposure estimates consider both everyday and accidental exposures, where doses are expressed in units of mg of absorbed dose per kilogram of body weight per pound of chemical handled. The exposure assumptions were derived using proposed application methods, application rates, the physical properties of the herbicides, and observational exposure data for workers mixing, loading, or applying pesticides.

Wildlife exposure estimates are developed for terrestrial animals and plants and aquatic organisms. Terrestrial animal exposure scenarios include ingestion of herbicide residues from vegetation, prey species, water, or through grooming activities, and dermal contact from direct spray or contact with contaminated vegetation. Exposure scenarios for terrestrial plants include unintended direct deposition or runoff.

**Demonstration Projects:** As discussed in the introduction to this chapter, risk characterizations for each herbicide are presented for both the Main Project and for Demonstration Projects 1 and 4, described in the Notice of Preparation/Initial Study.[1] Each section below addresses differences, if any, in the method of analysis for each situation. In many cases, doses are calculated on a per-acre basis. Per-acre dose values typically do not differ when comparing the Main Project to the two Demonstration Projects, with limited exceptions discussed individually below.

### 2.5.1 Application Guidelines and Exposure Scenario Categorization

Exposure estimates are calculated in this risk assessment for a set of scenarios that have some probability of occurring as a result of herbicide use. In order to determine which scenarios were plausible, we assumed that any applications would be conducted according to a set of guidelines created specifically for the Mount Sutro vegetation management project. The general strategy used was to present at least one scenario that represents a highly improbable, worst-case exposure event, and at least one scenario that represents a more probable event under the application conditions used on Mount Sutro. Scenarios were categorized qualitatively by the likelihood of occurrence.

#### *2.5.1.A UCSF Sutro Forest Vegetation Management Guidelines*

This section describes how, when, and where herbicides may be used to control or eliminate unwanted weed species on the Sutro Forest property. Exposures were estimated assuming that any application would be conducted in accordance with the following application guidelines.

#### Target Plants

The majority of the species of concern are invasive, non-native woody species, including but not limited to eucalyptus, broom, and blackberry. Other species of concern include non-native vines (ivy), veldt grass (*Ehrharta*), and poison oak growing near trails. It is proposed that herbicides will be used for controlling eucalyptus, ivy, Ehrharta, poison oak, blackberry, and other undesirable non-native vegetation where other techniques are known to be ineffective or prohibitively expensive.

#### Types of Herbicides

Aquamaster® (a glyphosate product that does not contain the more hazardous surfactants that Roundup® contains, EPA Registration # 524-343) would be used to spot-treat cut stems and/or foliage of target species such as veldt grass, poison oak, blackberry and broom. It is assumed that Competitor® would be used as a surfactant with the Aquamaster®, if needed. Blazon® blue dye would be used as the marker dye. As glyphosate must be applied within 30 minutes or less to a clean and free of debris stump, Garlon 4 Ultra® (formulated with modified seed oil, EPA Registration # 62719-527) may be used to treat tree stumps such as eucalyptus, acacia, and holly. Garlon 4 Ultra would be applied only to woody species that do not respond to Aquamaster,

including acacia, hawthorn, cotoneaster, and eucalyptus. It will be applied only as a cut stump application.

### Application Rates and Treatment Targets

The following list describes the target usage and maximum application rates for proposed herbicides, surfactants and dyes when initially applied. It is expected that in many cases, the amount used would be significantly less than the amounts shown below. Also, the amount will be substantially less during the five-year retreatment periods—just enough to treat any new sprouts or survivors, which are expected to decrease substantially with each year of retreatment. Details of application rates are provided below.

**Aquamaster**® (53.8% Glyphosate, isopropylamine salt)
Target usage:

- Understory shrubs and vines — 1-5 quarts per acre (1.25 to 4 lb a.e./acre)

**Garlon 4 Ultra**® **(**60.45% Triclopyr, butoxy ethyl ester)
Target usage:

- Cut stumps of trees — 1 to 4 quarts per acre (1-4 lb a.e./acre)

**Competitor**® (ethyl oleate, sorbitan alkylpolyethoxlate ester, dialkyl polyoxyethylene glycol)
Target usage:

- Surfactant for use with both herbicides — not more than 8 quarts per acre (14.8 lb a.i./acre)

**Blazon:**
Target usage:

- Dye for use with both herbicides — 4 ounces per acre (0.28 lb a.i./acre)

### Application Methods

Herbicides would be spot applied by a wick, sponge, squirt bottle or directed-spray applicator to cut stems or, for certain species such as Ehrharta, to foliage. UCSF has made a commitment to not conduct broadcast or widespread vegetation spraying.

### Exclusion Areas

Herbicides would not be applied within 100 feet of Christopher and Crestmont Streets or the backyards along Edgewood Avenue. Garlon would not be applied within 50 feet of a stream. Herbicides would also not be applied to any area where no vegetation is removed. These areas, which are generally too steep and inaccessible for equipment, consist of pockets of forest along the western and eastern edges that are estimated to compose about 10-15% of the Reserve. For purposes of the risk assessment, it is assumed that 48 acres of the total 62.7 acres would be treated with herbicides.

### Vegetation Treatment

Tree removal would be done using a large cutting machine (e.g., Brontosaurus) that chops up leaves, branches, and small stems and then distributes the cut material back on the ground surface as a rough mulch. Understory vegetation would be cut before the trees in order to allow herbicide application before the stems are buried by the additional mulch generated by the tree removal. These understory plants would be cut with a Brontosaurus where possible, and otherwise by hand crews.

### Retreatment

Some re-sprouting is anticipated because not all cut stems would be adequately treated and/or because new plants would appear from seeds or underground roots that escaped initial treatment. UCSF would spot-apply herbicide to retreat survivors, seedlings, or resprouts. The EIR will assume a maximum application rate of four pounds of active ingredient for the initial retreatment in the following year; two pounds of active ingredient in years 2-3, and one pound of active ingredients per acre for year 4-5.

### Maintenance

Herbicide use for ongoing maintenance will be evaluated in the EIR. This maintenance would primarily occur along the trails and native plant restoration areas to remove target species (primarily veldt grass, poison oak, non-native blackberry, and broom) from approximately ten feet on each side of the trail. The initial clearing along trails would be done by mowing or cutting the plants, and would be followed up with spot foliar or cut-stump herbicide applications to help suppress regrowth. All foliar applications would be of Aquamaster only. In some locations full-grown poison oak plants may be treated with foliar application without first being cut or mowed. Invasive species removal and herbicide reapplication would occur once per year. Ongoing maintenance will be assumed to use one pound of active ingredient per acre per year.

### Application Schedule

If herbicides are selected for future use, at most one-quarter of the portion of the Reserve that is being considered for herbicide use (approximately 48 acres) would be treated with the full vegetation treatment program, described above, in a given year. Additional acreage may be re-treated at the application rates described under the retreatment section, above, as necessary. The program of treatment and retreatment would occur annually for no more than five years on each 12-acre section. Maintenance treatment as described above would be ongoing. For a detailed description of the treatment schedule, see the Section 2.5.1.B below.

### EIR Analysis Approach

Initially, herbicides would be used in only one acre of Demonstration Project 1, and not used at all in Demonstration Projects 2 and 3. It is not yet known if herbicides would be used in Demonstration Project 4 so, for the purposes of our analysis, it is assumed that they would be. The EIR analysis will be two-pronged. The analysis will differentiate between the impacts and risks associated with the treatment of Demonstration Projects 1 and 4 and long-term impacts resulting from subsequent treatment (and retreatment) of up to 48 acres of the Reserve.

### Herbicide Use Restrictions

The application of herbicides would comply with all project guidelines set forth above, as well as the following specific Herbicide Use Restrictions:

1. Concentrated pesticide products are to be transported in a spill-proof, sealed container above and beyond the product container. The volume of concentrated product being transported on the site at any given time should be limited to less than 20 gallons.
2. All trailheads and other access points leading to the treatment area will be closed and posted prior to treatment in order to minimize exposures to the general public.
3. Treated areas will be posted for two weeks after the application to inform the general public of where applications have been conducted.
4. No applications will be conducted on weekends to minimize exposures to the general public..
5. All applications will be done by licensed applicators.
6. Any herbicide treatments will be conducted no earlier than June 1 to minimize the impact on nesting birds and no later than December 1, to avoid applications during the peak of the rainy season.
7. Applicators will wear gloves, protective footwear, goggles, and coveralls. An eyewash bottle and extra pairs of clean gloves, soap, and water will be available in each vehicle for washing if workers are exposed.
8. Mixer-loaders will wear gloves, rubber boots, goggles, coveralls, and a protective apron.
9. All mixing and loading will be done in a manner to contain any spills that might occur during transfers and will not be done near a water body.
10. Spill cleanup materials will be available in all vehicles used for herbicide applications.
11. If workers accidentally spill herbicide on themselves, they will be required to wash the affected area as soon as possible.

The following triclopyr-specific (Garlon 4) guidelines will also be employed. Generally speaking, triclopyr application leads to higher human and wildlife doses due to its higher dermal permeability. The following mitigations are designed to minimize hazardous dermal exposures to triclopyr:

1. No applications of Garlon will be conducted within 50 feet of a perennial or intermittent stream.
2. Two layers of gloves will be required for workers.
3. Backpack applicators that incorporate some form of physical separation between the backpack sprayer and the applicator are strongly recommended to prevent spills onto the applicator from a leaking backpack sprayer.

#### *2.5.1.B Application Schedule and Treatment Limitations*

The amount of herbicide used on Mount Sutro in a given year affects the risk profile of the project, specifically risks to aquatic animals and plants, risks to humans or animals drinking contaminated water, and risks to terrestrial mammals and birds eating contaminated vegetation, insects, or small mammals. UCSF has developed a treatment schedule, shown in Table 2-8 below, that would limit the amount of herbicide applied to the Reserve in any given year and thus minimize these risks.

### Treatment scenarios

PRI conducted the risk assessment for four treatment scenarios for consideration by UCSF in project planning. These scenarios bracket the range of risks for the treatment schedule outlined in Table 2-8, and assume that approximately 12 acres of the 62.7-acre reserve are too steep and inaccessible to be treated.

1) **Maximum treatment scenario:** All accessible acres (48 total) treated at the maximum application rate of 4 lbs a.e./acre;
2) **Half-treatment scenario:** Half the accessible acres (24) treated at the maximum application rate or all of the acres treated at 2 lbs a.e./acre; and
3) **Quarter-treatment scenario:** One-quarter (12) of the accessible acres treated at the maximum application rate or all of the acres treated at 1 lb a.e./acre.
4) **Demonstration project scenario:** Treatment of Demonstration Project areas #1 (one acre) and #4 (two acres) at the maximum application rate of 4 lbs a.e./acre.

### Proposed treatment schedule

In the initial treatment year, at most one-quarter of the 48 acres of the Reserve that is being considered for treatment with herbicides would be treated with herbicides at the maximum application rate of four pounds per acre (the Quarter-treatment scenario). In the second year, a new area of 12 acres would be treated with the maximum application rate of 4 lbs a.e./acre and re-sprouts on the initial 12-acre plot would be treated with spot spraying up to 4 lbs a.e./acre (the Half-treatment scenario). Herbicide application rates would drop to a maximum of 2 lbs a.e./acre in the third and fourth years and 1 lb a.e./acre in the fifth and sixth years of the project.

In general, the EIR will assume a maximum application rate of four pounds of active ingredient (as acid equivalents) for the initial treatment and retreatment in the second year; 2 lbs a.e./acre in years two and three, and 2 lbs a.e./acre in years 4-5. This program of treatment and retreatment would occur annually for no more than f years on each 12-acre section.

**Table 2-8: Mount Sutro Herbicide Treatment Schedule**

| | Maximum Lbs per Acre[a] | Maximum Acres Treated | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year DP[b] | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 |
| Demonstration Projects | 4 | 3 | | | | | | | | | |
| Initial treatment | 4 | | 12 | 12 | 12 | 12 | | | | | |
| First retreatment | 4 | | | 12 | 12 | 12 | 12 | | | | |
| Second retreatment | 2 | | | | 12 | 12 | 12 | 12 | | | |
| Third retreatment | 2 | | | | | 12 | 12 | 12 | 12 | | |
| Fourth retreatment | 1 | | | | | | 12 | 12 | 12 | 12 | |
| Fifth retreatment | 1 | | | | | | | 12 | 12 | 12 | 12 |
| **Maximum annual** | | | | | | | | | | | |
| Acres treated | | 3 | 12 | 24 | 36 | 48 | 48 | 48 | 36 | 24 | 12 |
| Lbs applied | | 12 | 48 | 96 | 120 | 144 | 108 | 72 | 48 | 24 | 12 |

[a] Excluding maintenance herbicide of one pound per acre annual maximum, proposed for use primarily along trails and native plant restoration areas to remove target species (primarily veldt grass, poison oak, non-native blackberry, and broom) from approximately ten feet on each side of the trail.

[b] "Year DP" indicates year of treatment for Demonstration Projects, which may or may not directly precede the following treatment years.

### *2.5.1.C Exposure Scenario Categorization and Probabilities*

Several different scenarios were developed to estimate potential exposures, some more probable than others. The worst-case scenarios are meant to provide an upper limit on exposure estimates. If such a scenario results in an exposure that is less than the Toxicity Reference value (a hazard quotient less than one), then the more probable exposures will have hazard quotients much less than one. The different exposure scenarios are categorized as "**Highly Probable**," "**Probable**," "**Possible**," "**Improbable**" and "**Highly Improbable**.**"** These five categories are used throughout the exposure estimates to designate the likelihood of each scenario occurring. Tables 2-8 through 2-11 provide a list of the primary exposure scenarios evaluated. Each of the scenarios includes a qualitative assessment of the likelihood of the scenario occurring.

Some exposure scenarios that are included in the USFS risk assessment spreadsheets are eliminated entirely by the Mount Sutro project design, and one new scenario is introduced. The use of the Brontosaurus and cut-stump herbicide application techniques is substantially different from foliar applications of herbicides to stands of vegetation and will vastly reduce the potential for exposure of humans and wildlife through spray drift, contact with treated foliage, and runoff. The potential for contact with treated stumps is introduced by the application methods and has been added to the list of exposure scenarios.

**Demonstration Projects and Exposure Scenarios:** Some exposure scenario probabilities will differ between the two Demonstration Projects and the Reserve as a whole. The reasons fall into a few categories—acres treated, days worked, seasonality and site-specific factors—and each case is addressed below.

### Table 2-9: Water Contamination Scenarios and Probability of Occurrence

| Scenario | | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|---|
| **Spill Scenarios** | | | | |
| Accidental spill | 20 gallons | **Highly Improbable** | **Highly Improbable** | Only a vehicle accident occurring at the intersection of Woodland Creek and the road could cause a spill of such a large volume into a water body. This scenario is less probable for Demonstration Projects because less herbicide will be transported to the sites due to the smaller area to be treated.<br><br>**Mitigations:** Limit vehicles carrying herbicides near Woodland Creek; use spill-proof containers. |
| | 1 gallon | **Improbable** | **Improbable** | A spill of this volume could result from mixing chemicals near water or spilling from a backpack sprayer. This scenario is less probable at demonstration sites because less herbicide will be handled at the sites, and because the demonstration sites are not immediately adjacent to Woodland Creek, though Demonstration Project 4 is upslope from Woodland Creek.<br><br>**Mitigations:** Mix chemicals away from waterways; designate dry stream crossings for workers; use spill-proof containers; use stream buffers. |
| **Herbicide-Contaminated Runoff Scenarios** | | | | |
| Peak runoff to Woodland Creek; during a large storm | | **Probable (Site 4) Eliminated (Site 1)** | **Probable** | Peak rainfall runoff immediately after an application would result in herbicide runoff from an application conducted during the rainy season once soils have reached saturation. This scenario is considered **Probable** due to the window of application dates specified for Mount Sutro (June 1–December 1). The probability is the same for the Demonstration plot #4, because it is in the Woodland Creek watershed, but no runoff to Woodland Creek will occur from treatment of Demonstration Plot #1. The probability of herbicide runoff increases if application occurs late in the treatment window.<br><br>**Mitigations:** Apply herbicides prior to Sept. 15 to provide at least 30–60 days between the application and a rainstorm sufficient to generate runoff; use stream buffers. Do not apply when rain is predicted. |
| Long-term runoff to Woodland Creek; over the course of several months after an application | | **Probable (Site 4) Eliminated (Site 1)** | **Probable** | Rain 0-120 days after application is likely to occur, due to the window of application dates specified for Mount Sutro (June 1–December 1), and some of the herbicide and its breakdown products could potentially run off with storm water. The probability is the same for the Demonstration plot #4, because it is in the Woodland Creek watershed, but no runoff to Woodland Creek will occur from treatment of Demonstration Plot #1. The probability of herbicide runoff increases if application occurs late in the treatment window;<br><br>**Mitigations:** Minimize herbicide use where possible; use stream buffers; Treat areas closest to streams early in dry season to maximize degradation period prior to onset of rains. |

| Scenario | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|
| **Wastewater Treatment Plants (WWTPs)**<br>Peak runoff to WWTPs | **Probable** | **Probable** | Contamination of San Francisco's Oceanside and Southeast wastewater treatment plants by peak runoff is considered Probable due to the window of application specified for Mount Sutro (June 1-December 1). See notes and mitigations for spills and peak runoff in Table 2-9 above. The probability is the same for the Demonstration Projects, which drain to the Oceanside (Demonstration Project #1) and Southeast (Demonstration Plot 4) plants. The probability of water contamination increases if application occurs late in the treatment window.<br><br>**Mitigations**: See notes for peak runoff to Woodland Creek above. |
| Long-term runoff to WWTPs; during several months after an application | **Not considered** | **Not considered** | Long-term runoff to wastewater treatment plants is not considered because peak runoff is responsible for carrying the majority of herbicide off-site, resulting in lower estimated concentrations than for than peak runoff, concentrations that already do not approach levels of concern.<br><br>**Mitigations**: See notes for long-term runoff to Woodland Creek above. |

**Table 2-10: Worker Exposure Scenarios and Probability of Occurrence**

| Scenario | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|
| **Accidental** | | | |
| Wearing contaminated gloves for 1 minute | **Probable** | **Probable** | Chemical residues are likely to get into workers' gloves during herbicide applications.<br><br>**Mitigations:** Train workers to wash hands and change gloves regularly; require use of on-site wash stations; have extra clean gloves available at the work site. |
| Wearing contaminated gloves for 1 hour | **Improbable** | **Improbable** | Chemical residues can contaminate gloves, but it is unlikely that workers will continue working with contaminated gloves for one hour.<br><br>**Mitigations**: Train workers to wash hands regularly; require on-site wash stations to be available; have extra clean gloves available at the work site. |
| Spill on hands, unwashed for 1 hour<br>Spill on lower legs, unwashed for 1 hour | **Improbable** | **Improbable** | Spills to bare skin are unlikely if proper PPE is used.<br><br>**Mitigations:** Require PPE and worker training for applicators; require additional PPE (aprons, rubber boots) for workers mixing pesticides; require on-site wash stations to be available. |
| **General** | | | |
| General Worker – Backpack spray general exposure | **Highly Probable** | **Highly Probable** | Biomonitoring studies indicate that chemical exposure is unavoidable when applying herbicides. See Section 2.2.3 for more information. |
| General Worker – Cut-stump general exposure | **Highly Probable** | **Highly Probable** | **Mitigations:** Require PPE and worker training to minimize exposures. |

PPE = Personal protective equipment.

### Table 2-11: General Public Exposure Scenarios and Probability of Occurrence

| Scenario | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|
| **Acute** | | | |
| Direct spray of entire child's body | **Highly Improbable** | **Highly Improbable** | This event is only used to calculate exposures for a worst-case scenario and is not in the realm of possibility. Treating demonstration sites requires fewer acres to be treated with directed herbicide spray than the Reserve as a whole; likelihood of exposure is proportionately less. |
| Direct spray of woman's lower legs | **Highly Improbable** | **Highly Improbable** | A direct spray to a person would only occur if the applicator were not paying attention to what she/he was spraying and if a person accidentally walked into the application site during an application in spite of posted warning signs and the applicator continued to work. The use of a wick, squirt bottle or paintbrush to treat large stumps and the use of sprays to treat cut stems close to the ground will significantly reduce the likelihood of spray drift. Treating demonstration sites requires fewer acres to be treated with directed herbicide spray than the Reserve as a whole; therefore, the likelihood of exposure is proportionately less.<br><br>**Mitigations:** Train workers to stop applications immediately when another person approaches the site; post the area prior to the application; do not apply on weekends. Ensure that vegetation is cut close to the ground prior to treatment. |
| Brushing against contaminated vegetation | **Improbable (Glyphosate)**<br><br>**Eliminated (Triclopyr)** | **Possible (Glyphosate)**<br><br>**Eliminated (Triclopyr)** | Most vegetation will be cut and mulched prior to treatment of cut stems, and re-sprouts will be cut prior to treatment. However, directed spray of certain species such as *Ehrharta* may occur; this directed spray could expose individuals who enter the Reserve soon after treatment and encounter areas treated by directed spray. Treating demonstration sites requires fewer acres to be treated than the Reserve as a whole; therefore, the likelihood of exposure is proportionately less. Triclopyr will not be used for foliar applications, therefore this exposure pathway has been eliminated for triclopyr.<br><br>**Mitigations:** Use marker dye for all foliar applications. Post the area prior to the treatments and leave signs up for two weeks afterward; do not apply on weekends. |
| Cut-stump contact<br>(Sitting on a treated stump) | **Improbable** | **Possible** | A hiker may decide to sit on or touch a treated stump, and there are a number of trees near the trail that may be treated. Although signs and dyes will provide warnings, this scenario is possible. Treating demonstration sites requires fewer acres to be treated with herbicide than the Reserve as a whole; therefore, the likelihood of exposure is proportionately less.<br><br>**Mitigations:** Use marker dye for all cut-stump applications. Post the area prior to the treatments and leave signs up for two weeks afterward; do not apply on weekends. |
| Eating contaminated fruit | **Eliminated** | **Eliminated** | This exposure scenario is eliminated by the Mount Sutro project design. Blackberry bushes will be cut and mulched prior to treatment of cut stems, and re-sprouts will not bear fruit until the second year after cutting. Since follow-up treatment is planned each year, re-sprouts will be cut before they can bear fruit. |

| Scenario | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|
| Drinking contaminated water after accidental spill into Woodland Creek or to puddles/pools | **Highly Improbable** | **Highly Improbable** | Spills into Woodland creek or puddles/pools are considered highly improbable, due to applicator precautions, as is drinking directly from the creek, which would be possible only near the end of the treatment window, when rains cause the intermittent creek to flow. Additionally, creek access is limited, which will further reduce the probability of a person drinking from the creek. Demonstration Site 4 drains to the Woodland Creek watershed, but represents only a fraction of the watershed thus, the likelihood of contamination is proportionately less than that for the entire project. Demonstration Site 1 does not drain to any potential drinking water source. Drinking from puddles or pools is also considered Highly Improbable. |
| Drinking contaminated water from Woodland Creek after peak runoff | **Highly Improbable (Site 4) Eliminated (Site 1)** | **Highly Improbable** | Peak runoff is considered Probable, as described in Table 2-9 above. However, drinking contaminated water is unlikely because the creek is not a formal drinking water source, nor is it readily accessible to hikers. The probability is the same for the Demonstration plot #4, because it is in the Woodland Creek watershed, but no runoff to Woodland Creek will occur from treatment of Demonstration Plot #1. See "Drinking contaminated water after accidental spill" above regarding Demonstration Projects.<br><br>**Mitigations:** See mitigations for spills and peak runoff in Table 2-9 above. |
| **Chronic** | | | |
| Eating contaminated fruit | **Eliminated** | **Eliminated** | Same as acute scenario for eating contaminated fruit. See Eating contaminated fruit above. |
| Drinking water from Woodland Creek after long-term runoff | **Highly Improbable (Site 4) Eliminated (Site 1)** | **Improbable** | Rain 0-120 days after application is likely to occur, due to the window of application dates specified for Mount Sutro (Section 2.5.1.A above), and some of the non-degraded herbicide could run off into water bodies. Herbicide degradation after treatment is accounted for when estimating exposures. However, it is considered Improbable that the general public would drink regularly from runoff-contaminated water bodies in or near the Reserve. Demonstration Site 4 drains to the Woodland Creek watershed, but represents only a fraction of the watershed thus, the likelihood of contamination is proportionately less than that for the entire project. Demonstration Site 1 does not drain to any potential drinking water source.<br><br>**Mitigations:** Minimize herbicide use where possible. Avoid drips near treated stumps/stems. Use stream buffers. |

**Table 2-12: Wildlife Exposure Scenarios and Probability of Occurrence**

| Scenario | | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|---|
| **Acute Exposures to Terrestrial Wildlife** | | | | |
| Direct spray of small mammal | | | | |
| First-order absorption | | **Improbable** | **Possible** | Wildlife that are difficult to detect could be sprayed.<br><br>**Mitigations**: Mow or trim tall vegetation prior to application. |
| 100% absorption | | **Highly Improbable** | **Improbable** | Hidden wildlife or insects could be sprayed, but it is unlikely that the organism will ingest/absorb 100% of the intercepted spray. See mitigations for first-order absorption above. |
| Eating vegetation/fruit on-site[a] or off-site | Small mammal | **Possible** | **Possible** | Blackberries will be cut and mulched prior to treatment, minimizing the available forage; however, small mammals can reasonably be expected to eat any berries that have fallen to the ground prior to or during cutting that may be exposed to drips or spray from a backpack sprayer; therefore, exposure is **Possible**. Large birds may eat treated grasses; however, the area with grass is quite small on Mount Sutro overall and even less for the Demonstration Projects. There are no large herbivorous mammals living on Mount Sutro, therefore the scenario of large mammals eating vegetation is eliminated. |
| | Large bird | **Improbable** | **Improbable** | |
| | Large mammal | **Eliminated** | **Eliminated** | |
| Drinking contaminated water after accidental spill | Small mammal<br>Carnivorous mammal<br>Small bird<br>Large bird | **Improbable** | **Improbable** | Spills are considered Improbable due to precautions described in Table 2-9 above. Treating Demonstration Site 4 exposes Woodland Creek, from which animals can drink, but the exposure is less than when the entire Woodland Creek watershed is treated; therefore, the likelihood of exposure is proportionately less. Treating Demonstration Site 1 is unlikely to contaminate potential drinking water sources because there is no surface water at the site.<br><br>**Mitigations:** See mitigations for spills in Table 2-9 above. |
| after peak runoff to Woodland Creek | Small mammal<br>Carnivorous mammal<br>Small bird<br>Large bird | **Probable (Site 4)**<br>**Eliminated (Site 1)** | **Probable** | Exposure to herbicides from drinking water after peak runoff to Woodland Creek is considered Probable due to the window of application specified for Mount Sutro and the fact that wildlife will use any available water source. The probability is the same for the Demonstration plot #4, because it is in the Woodland Creek watershed, but no runoff to Woodland Creek will occur from treatment of Demonstration Plot #1. The probability of drinking contaminated water decreases if application occurs late in the treatment window.<br><br>**Mitigations:** See mitigations for peak runoff in Table 2-9 above. |
| Eating contaminated insects | Small mammal<br>Small bird | **Possible** | **Possible** | It is considered **Possible** that insects could be sprayed. Insectivores may then eat contaminated prey. |

| Scenario | | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|---|
| Eating contaminated small mammal<br>Carnivorous mammal<br>Carnivorous bird | | **Improbable** | **Possible** | If small mammals are hidden, it is considered Possible that they will be sprayed. Carnivores may then eat contaminated prey. Treating demonstration sites requires fewer acres to be treated with herbicide than the Reserve as a whole; the likelihood of exposure is proportionately less. |
| **Chronic Exposures to Terrestrial Wildlife** | | | | |
| Eating vegetation/fruit, On-site | Small mammal[b] | **Improbable** | **Possible** | Blackberries will be cut and mulched prior to treatment, minimizing the available forage; however, small mammals can reasonably be expected to eat any berries that have fallen to the ground prior to or during cutting that may be exposed to drips or spray from a backpack sprayer. |
| | Large mammal[b] | **Eliminated** | **Eliminated** | There are no large herbivorous mammals living on Mount Sutro. |
| | Large bird[b] | **Highly Improbable** | **Improbable** | Large birds may eat treated grasses, although long-term exposure is considered **Improbable** because dead grasses are not likely to be consumed and the area with grasses is quite small on Mount Sutro. The demonstration sites contain little if any grass, so the likelihood of exposure is **Highly Improbable.**<br><br>**Mitigations:** Cut tall vegetation prior to treatment; avoid spraying palatable plants. |
| Eating vegetation/fruit, Off-site | Small mammal[b] | **Highly Improbable** | **Highly Improbable** | Off-site exposure is Highly Improbable because treatment methods are highly targeted. Treating demonstration sites requires fewer acres to be treated with herbicide than the Reserve as a whole; likelihood of exposure is proportionately less. |
| | Large bird[b] | **Highly Improbable** | **Highly Improbable** | Off-site exposure is Highly Improbable because treatment methods are highly targeted. Treating demonstration sites requires fewer acres to be treated with herbicide than the Reserve as a whole; likelihood of exposure is proportionately less.<br><br>**Mitigations:** See mitigations for chronic exposures above. |
| Drinking water, after long-term runoff to Woodland Creek | Small mammal<br>Large mammal<br>Carnivorous mammal<br>Small bird<br>Large bird | **Probable (Site 4)**<br>**Eliminated (Site 1)** | **Probable (Site 4)**<br>**Eliminated (Site 1)** | Rain 0–120 days after application is likely to occur, due to the window of application dates specified for Mount Sutro, and some of the non-degraded herbicide could run off into water bodies. The probability is the same for the Demonstration plot #4, because it is in the Woodland Creek watershed, but no runoff to Woodland Creek will occur from treatment of Demonstration Plot #1. The probability of drinking contaminated water decreases if application occurs late in the treatment window.<br><br>**Mitigations:** See notes for long-term runoff in Table 2-9 above. |

| Scenario | Qualitative Probability of Occurrence: Demonstration Sites 1 and 4 | Qualitative Probability of Occurrence: Main Project | Comments |
|---|---|---|---|
| **Aquatic Organisms** | | | |
| Acute, accidental spill<br>Amphibians<br>Aquatic Invertebrates<br>Aquatic Plants | **Highly Improbable** | **Highly Improbable** | Spills are considered Improbable to Highly Improbable for the Main Project (see Table 2-9 above); in addition, should a spill occur, it will not necessarily be near water and aquatic organisms. So this scenario is deemed Highly Improbable. Treating Demonstration Site 4 creates the possibility of a spill that reaches Woodland Creek. At Demonstration Site 1, amphibians could be exposed in puddles. However, exposure is less probable at demonstration sites because fewer acres will be treated and less time will be spent handling herbicide in these areas.<br><br>**Mitigations:** See notes for spills in Table 2-9 above. |
| **Woodland Creek**<br>Acute, peak runoff to Woodland Creek<br>Amphibians<br>Aquatic Invertebrates<br>Aquatic Plants | **Probable (Site 4)**<br>**Eliminated (Site 1)** | **Probable** | Contamination of Woodland Creek by peak runoff is considered Probable due to the window of application specified for Mount Sutro (June 1-December 1). The probability is the same for the Demonstration plot #4, because it is in the Woodland Creek watershed, but no runoff to Woodland Creek will occur from treatment of Demonstration Plot #1. The probability of water contamination increases if application occurs late in the treatment window.<br><br>**Mitigations:** See notes for peak runoff in Table 2-9 above. |
| Chronic, Long-term runoff to Woodland Creek; during several months after an application<br>Amphibians<br>Aquatic Invertebrates<br>Aquatic Plants | **Probable (Site 4)**<br>**Eliminated (Site 1)** | **Probable** | Rain 0-120 days after application is likely to occur, due to the window of application dates specified for Mount Sutro (June 1–December 1), and some of the herbicide and its breakdown products could potentially run off with storm water. The probability is the same for the Demonstration plot #4, because it is in the Woodland Creek watershed, but no runoff to Woodland Creek will occur from treatment of Demonstration Plot #1. The probability of herbicide runoff increases if application occurs late in the treatment window;<br><br>**Mitigations:** See notes for long-term runoff in Table 2-9 above. |
| **Wastewater Treatment Plants (WWTPs)**<br>Acute, peak runoff to WWTPs<br>Fish<br>Aquatic Invertebrates<br>Aquatic Plants | **Probable** | **Probable** | Contamination of San Francisco's Oceanside and Southeast wastewater treatment plants by peak runoff is considered Probable due to the window of application specified for Mount Sutro (June 1-December 1). See notes and mitigations for spills and peak runoff in Table 2-9 above. The probability is the same for the Demonstration Projects, which drain to the Oceanside (Demonstration Project #1) and Southeast (Demonstration Plot 4) plants. The probability of water contamination increases if application occurs late in the treatment window.<br><br>**Mitigations:** See notes for peak runoff in Table 2-9 above. |
| Chronic, Long-term runoff to WWTPs; during several months after an application | **Not considered** | **Not considered** | Long-term runoff to wastewater treatment plants is not considered because peak runoff is responsible for carrying the majority of herbicide off-site, resulting in lower estimated concentrations than for than peak runoff, concentrations that already do not approach levels of concern. |

[a] The fraction of an herbivore's diet that is consumed on-site in this risk assessment was varied, with values of 10%, 30% and 100% used for acute exposure estimates.
[b] Chronic scenarios were evaluated for wildlife eating vegetation both at the application site ("on-site") and near the application site that may have received some spray drift, but not in the treated area ("off-site"). In the on-site chronic scenarios, the default Central, Lower, and Upper estimates assume that the herbivore spends 30%, 10%, and 100% of its time eating on-site. For the acute exposure estimates, it is assumed that wildlife spend all of their time on-site. For off-site vegetation consumption estimates, it is assumed that herbivores consume all of their food from vegetation that is 25, 50 or 100 feet away from the application site

### 2.5.2 Water Contamination Scenarios

Mount Sutro encompasses thirteen distinct watersheds, each of which drains to the city stormwater system destined either for the Pacific Ocean via San Francisco's Oceanside wastewater treatment plant or for San Francisco Bay via the Southeast wastewater treatment plant. A map of the watersheds on Mount Sutro is provided in Figure 2-4 below. Woodland Creek is a high-gradient wet-weather drainage in one of the Mount Sutro watersheds that serves as a water supply for wildlife. Additionally, in the flatter parts of the project area, puddles that may serve as breeding habitat for amphibians form from both precipitation and fog. Depressions and ruts from the use of heavy equipment in the reserve are likely to increase the number of such puddles. This risk assessment provides an estimate of herbicide concentrations in each of these three water bodies.

Herbicide concentration estimates are used to assess drinking water exposures for terrestrial wildlife and humans, as well as exposures for aquatic wildlife. Throughout this document, the word "contaminated" is used to mean that any amount of a chemical residue is present. "Contaminated" does not necessarily equate to hazardous, but indicates only that the compound is present at some level.

We present three **acute** and two **chronic** scenarios for contamination of water from herbicide applications. The three acute scenarios are evaluated for three different water bodies—a puddle or small pool, Woodland Creek, and either San Francisco Bay or the Pacific Ocean, discussed in Section 2.5.2.E below. The chronic scenarios are evaluated for contamination of Woodland Creek or for runoff to either San Francisco Bay or the Pacific Ocean via San Francisco's stormwater system, discussed in Section 2.5.2.G below.

If the concentration calculated using this approach divided by the appropriate Toxicity Reference Values (TRVs) or Reference Doses (RfDs) produces Hazard Quotients (HQs) less than 0.1, there is an extremely low probability that herbicide use in the watershed will have adverse effects. Alternatively, if HQ's exceed 0.1, there is potential for adverse effects, and mitigation measures will need to be implemented.

The acute and chronic runoff scenarios require the use of both generic and chemical-specific parameters for estimating water contamination rates. Generic parameters used in the calculations are shown in Table 2-13.[78] Chemical-specific parameters are included in the chapters on the specific active ingredients.

#### *2.5.2.A Site-Specific Weather Patterns near Mount Sutro*

The potential for herbicide runoff and water contamination is highly dependent on the timing of herbicide applications relative to rain events. With a window for herbicide applications on Mount Sutro of June 1 to December 1, a storm with sufficient rainfall to cause significant runoff is possible.

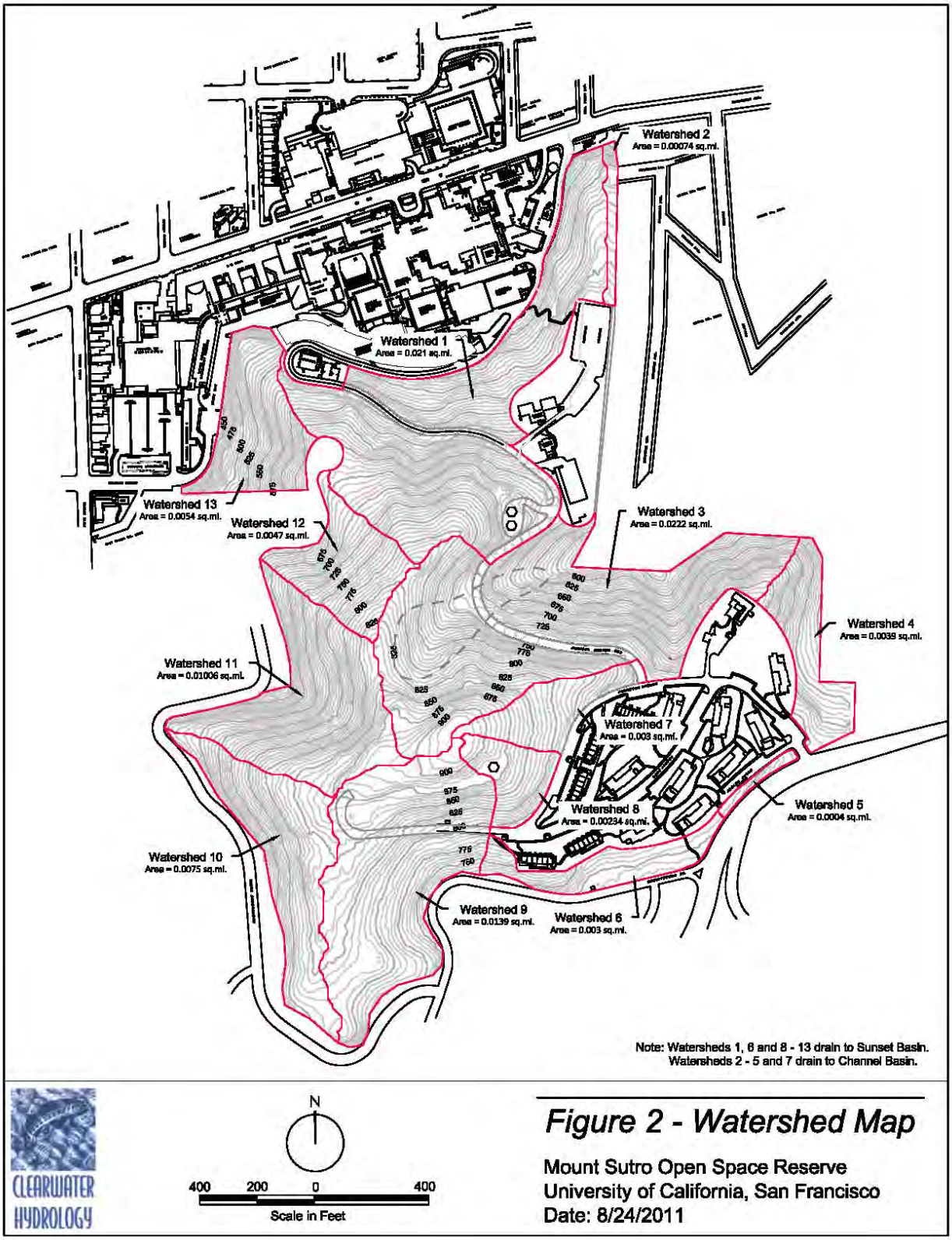



**Figure 2-4:** Watersheds of Mount Sutro. *Source:* Clearwater Hydrology.

**Table 2-13: Water Body and Spill Parameters Used for Mount Sutro Exposure Scenarios**

| Parameter | Lower Estimate | Central Estimate | Upper Estimate |
|---|---|---|---|
| Volume of puddle (L) | 5 | 50 | 100 |
| Wet-weather capacity of Oceanside WWTP (MGD) | 43 | 43 | 43 |
| Wet-weather capacity of Southeast WWTP (MGD) | 110 | 110 | 110 |
| Volume of accidental spill into Woodland Creek (gal) | 1 | 10 | 20 |
| Volume of accidental spill into puddle/pool | 1 | 1 | 1 |
| Decay time between application and heavy rain (days) | 120 | 60 | 0 |

MGD = million gallons per day; WWTP = wastewater treatment plant. *Data source:* Wet-weather capacities, Reference 78.

San Francisco County has mild rainy winters and a dry season that typically lasts from June to October. Figure 2-5 shows median daily rainfall in downtown San Francisco from 1971-2000 as an approximation of rainfall at Mount Sutro. Each rainfall value reported is a thirty-year median of observations in the given month, so in half of the 30 years observed, actual rainfall each year was greater than the median values presented and in half of the years observed, actual rainfall was less than the median values presented. Due to topography, Mount Sutro may experience more rain than downtown San Francisco, a caveat that should be considered when interpreting the weather data below. Mount Sutro and nearby peaks have a rain shadow effect, encountering storms coming in from the Pacific Ocean before those storms reach downtown, to the east.

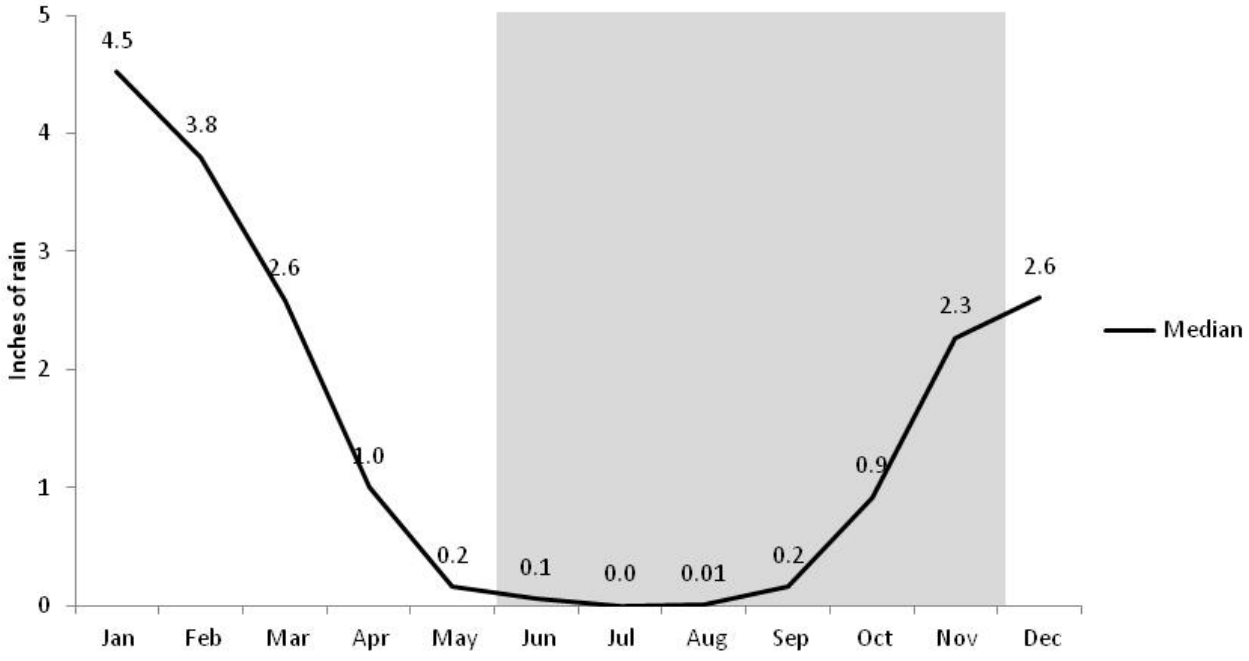



**Figure 2-5:** Thirty-year median of monthly rainfall in downtown San Francisco, 1971-2000. The proposed window of herbicide application is indicated in gray. *Source:* Reference 79.

The data demonstrate that San Francisco rainfall is highly seasonal. For example, Figure 2-5 indicates a median of 0.11 inches (less than 0.5 percent of annual rainfall) occurred between June 1 and September 1 in the 30-year period described. In contrast, a median 5 percent of annual

rainfall was recorded for October and 12.5 percent for November. Figure 2-6 below, based on the same data, shows the average number of days per month in which rainfall exceeded 0.01, 0.1, 0.5 or 1 inches in downtown San Francisco from 1971-2000. Of the 91 days between June 1 and September 1, rainfall of 0.1 inches or more did not occur more than one day over the 30 years captured by the data. Days of heavier rain (0.5 inches or more) were apparently not recorded at all during that thirty-year period. During September, heavy rainfall was rare: Rain exceeding 0.5 inches occurred with a probability equivalent to one day in ten years.

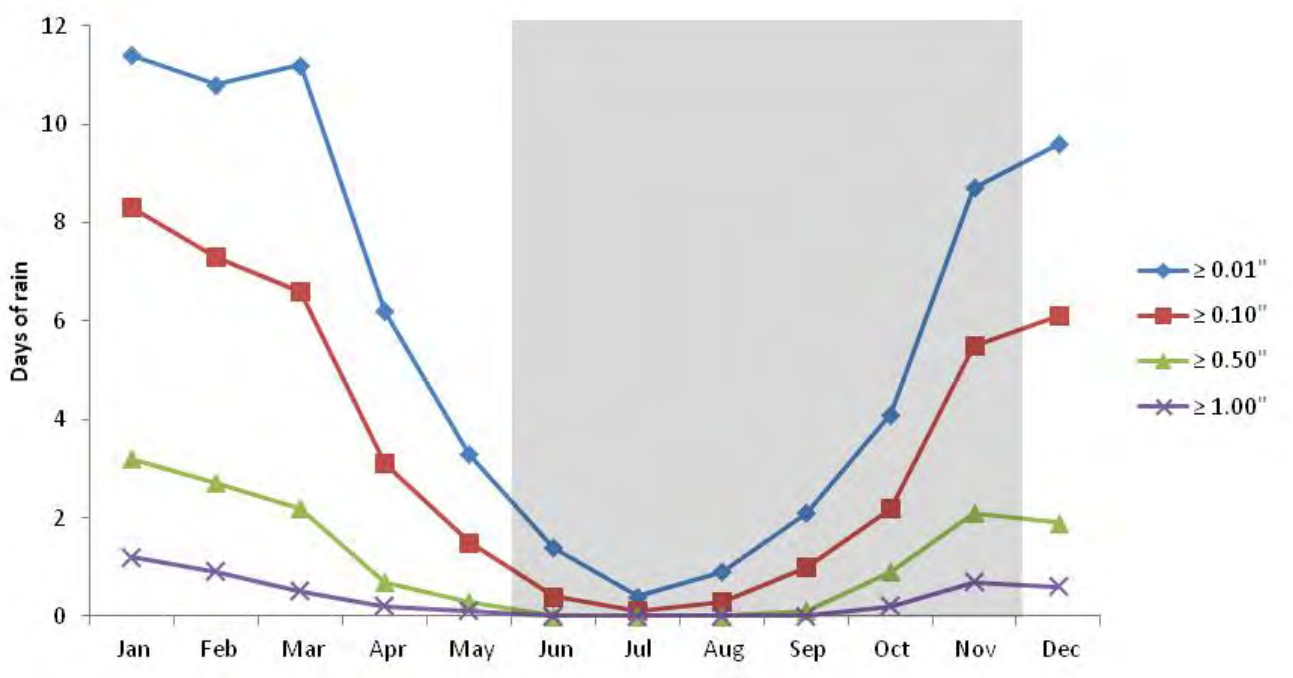



**Figure 2-6:** Thirty-year median of the number of days per month in which rainfall exceeded 0.01", 0.1", 0.5" or 1" in downtown San Francisco, 1971-2000. The proposed window of herbicide application is indicated in gray. *Source:* NOAA 2004, Reference 79.

For October and November, the incidence of rainy days increases significantly. Rain days of 0.1 inches or more in October increased to an average of 2.2 days per month, a figure that includes heavier rain days (0.5 inches or more) of nearly one day per month on average. In November, rainy days increased to an average of 5.5 days per month with 0.1 inches of rain or more, and an average of 2.1 days of heavy rain (0.5 inches or more). Very heavy rain (1 inch or more) was recorded in November at a rate of 0.7 days per month.

Because the ground is likely to be fairly dry by June 1, it is unlikely that rain events early in the application season would cause significant runoff. However, any treatment conducted late in the June–December treatment window would significantly increase the probability of contaminated runoff occurring. Section 2.5.2.G below describes the changes PRI made to the calculations to account for the intervening dry period between applications and rainfall sufficient to cause runoff.

### *2.5.2.B USFS/SERA Water Contamination Rates from GLEAMS Modeling*

The peak and long-term runoff scenarios were designed by the USFS to provide an estimate of herbicide concentrations in water after rain events. One method used to calculate the concentration of the chemical in the water body is the water contamination rate that predicts concentrations of herbicide in mg/L based on pounds of herbicide applied per acre. These rates are derived from the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model.

In practice, the water contamination rate is a function of the number of acres treated, the application rate, the size of the receiving water body, the intensity of the rain event, the distance between the water body and the application site, the topographical and soil characteristics of the site, and the time between application and runoff. We used the USFS/SERA worksheets to calculate the water contamination rate, which uses the following parameter options:

1. Herbicides were applied to 10 acres directly adjacent to a pond (one million liters) or a stream with flow rate of 710,000 liters/day or 710 $m^3$/day.
2. Annual rainfall was assumed to be 5, 10, 15, 20, 25, 50, 100, 150, 200, or 250 inches occurring evenly throughout the year at regular 10-day intervals.
3. Three types of soil were modeled: clay, loam and sand.
4. Daily concentrations were averaged over the year, and the maximum concentration within a given year was recorded.

The results of these calculations were presented in the USFS/SERA worksheets for both a stream and a pond; however, only the stream scenario is relevant to the Mount Sutro project. Lower, Central and Upper water contamination rates for peak and long-term runoff scenarios were selected by USFS to be protective and produce slightly higher concentrations than most that have been observed in field studies, with a few exceptions. The Upper estimate for the peak water contamination rate was chosen as the maximum observed rate in sandy soils with a rainfall rate of 250 inches per year. The Lower estimate is described as “arbitrary” since arid environments are unlikely to experience substantial runoff, except on rare occasions, which would match the summer dry season for Mount Sutro when no rainfall is anticipated.

Because the GLEAMS parameters used to develop the USFS/SERA water contamination rates are not a perfect fit for the Mount Sutro site, the resulting water contamination rates may be over- or under-estimated under certain circumstances. In the sections below, we discuss these two possibilities. The reader is referred to the latest USFS risk assessment for a detailed discussion of the methods used to obtain the water contamination rate.[12, 22]

### *2.5.2.C Why the USFS/SERA Model Might Overestimate Herbicide Concentrations in Water*

The USFS worksheets may ***overestimate*** water contamination rates in the Mount Sutro runoff for several reasons, including:

1. The model assumes that runoff occurs to a small pond or stream directly adjacent to the application site, whereas UCSF plans to employ buffer zones for triclopyr of 50 feet from Woodland Creek and runoff channels, thus triclopyr concentrations may be

overestimated. For glyphosate however, applications may occur in the streambed and this assumption correctly models the Mount Sutro situation.

2. The model assumes runoff into a stream with a flow rate of 710,000 L/day. However, the peak flow rate of Woodland Creek for the 5-year storm was estimated to be 18,594,000 L/day.[84] A larger flow rate will dilute herbicide concentrations further.
3. There are no small ponds on Mount Sutro, though puddles occur according to microtopography, including ruts created by machinery that will be used to remove trees. For the Woodland Creek watershed, the more probable scenario would be for runoff to flow into the creek. Other than Woodland Creek, the water bodies receiving herbicide runoff from Mount Sutro would be San Francisco Bay and the Pacific Ocean, whose volumes are highly disproportionate to the small pond used in USFS calculations and would rapidly and substantially dilute herbicide concentrations. We developed an alternate method for estimating concentrations for this scenario (see Section 2.5.2.H).
4. The water contamination rates were chosen for sites with more rainfall than San Francisco, up to 250 inches/yr compared to San Francisco's 25 inches/yr.
5. In the model, rain is assumed to fall soon after herbicide applications are conducted. However, San Francisco has an extended dry season with essentially no precipitation from May through September, which means that herbicides applied before the rainy season will at least partially degrade during the time between the herbicide application and rainfall sufficient to cause runoff.

#### *2.5.2.D Why the USFS/SERA Model Might Underestimate Herbicide Concentrations in Water*

The modeling done by the USFS using GLEAMS may result in an *underestimate* of water contamination rates for the Mount Sutro project for only one reason: The water contamination rates used in the USFS/SERA worksheet calculation may not adequately reflect the topographical and soil type differences between the simulated runoff situation and the actual topography and soils of the site. Mount Sutro is very steep in many places where invasive vegetation grows. Runoff from these sites is likely to be higher than that in the studies from which the runoff rates were estimated for the GLEAMS model, which was developed for agricultural lands with little or no slope. Counteracting this potential for higher runoff is the presence of a significant amount of leaf litter, as well as any new mulch created by the vegetation removal project, which would serve to adsorb herbicides and minimize off-site transport. In a study of glyphosate runoff in Marin County conducted by the Marin Municipal Water District, no detectable herbicides were measured in runoff from test plots treated at 2 lbs a.e./acre, a fact that was attributed to the deep leaf litter on the site.[80] Thus, we believe that the risk estimates for water contamination from runoff are highly conservative and likely overestimate concentrations for most runoff scenarios.

#### *2.5.2.E Accidental Spills*

Several accidental spill scenarios were evaluated: One and 20 gallons of herbicide into Woodland Creek; and one gallon into puddles/pools of 5, 50 and 100 liters in volume. Large spills (20 gallons) are considered **Highly Improbable** and only as a result of an accident in which a vehicle carrying 20 gallons of herbicide is involved in an accident precisely at the location where Woodland Creek intersects the road. Smaller spills (one gallon) are considered **Improbable**. Spills to land are not considered, but would result in significant contamination that

would be highly problematic for terrestrial and aquatic wildlife (and to any humans drinking out of these puddles) if not cleaned up with absorbent materials and disposed of properly.

The equation for calculating the concentration of herbicide in water for acute accidental spills is shown below.

$$\text{Concentration (mg/L)} = \frac{\left(\begin{array}{c}\text{volume}\\ \text{spilled (L)}\end{array}\right) \times \left(\begin{array}{c}\text{herbicide}\\ \text{concentration (mg/L)}\end{array}\right)}{\text{volume of water body (L)}}$$

The small pond scenario was used as a worst-case scenario for an acute spill into a small volume of water such as a puddle, pond or Woodland Creek during low-flow conditions.

An accidental spill of both concentrated and diluted herbicide products into Woodland Creek might be envisioned to occur if:

- A truck carrying herbicides ran off the road where it crosses the creek, and all containers on the truck emptied into the creek (**Highly Improbable**);
- A container filled with herbicide fell into the creek and all contents spilled (**Improbable**);
- A compromised pesticide container leaked small amounts of herbicide into the creek (**Improbable**).

Spills into Woodland Creek were handled as a point discharge of either concentrated or dilute herbicide to a pool, with volume defined by the base stream flow rate in winter conditions without added rainfall. This is a realistic assumption of stream flow for days on which acute spills might occur, since workers are not expected to be applying herbicides on rainy days. The source of the creek flow on such days is primarily groundwater discharge to the channel between storm events, the amount of which depends on when precipitation events last occurred and the extent of groundwater recharge from prior storm events. A base flow rate was estimated by Clearwater Hydrology at 0.2–0.3 cubic feet per second (cfs).[81] For the Upper concentration estimate, we assumed a worst-case maximum concentration by assuming a spill into a low-flow section of Woodland Creek (similar to a pool) over the course of 60 seconds at the lowest flow rate of 0.2 cfs.

$$0.2 \text{ cfs} \times 60 \text{ seconds} = 12 \text{ ft}^3 = 340 \text{ L}.$$

We used flow rates of 0.5 cfs and 1.0 cfs, with corresponding volumes of 850 L and 1,700 L, for Central and Lower concentration estimates. Because the slope of the Woodland Creek watershed is steep (33% grade),[84] the continuous flow of the creek will dilute herbicide concentrations significantly within a few hours, but all points downstream of a spill will be exposed to elevated concentrations of herbicide as the “plug” of herbicide-contaminated water from the spill flows down the stream bed.

### *2.5.2.F Peak Runoff Based on USFS/SERA Water Contamination Rates*

In the event of a rainstorm, herbicide will be transported away from treated areas by runoff once soil becomes saturated. This scenario is considered increasingly likely to occur with the increasing likelihood of soil saturation later in the window of time that treatment is being considered (this probability is discussed in Table 2-9). The amount of herbicide that is lost in runoff is a function of the amount of herbicide applied, the proximity of treatment to drainages, and time elapsed after the application (because herbicides degrade over time).

Peak or "short-term" runoff estimates are designed to model pesticide concentrations in runoff from a heavy rain occurring soon after an herbicide application to already wet soils. The short-term water contamination rate model is based on an assumption of ten acres treated adjacent to a stream with a flow rate of 4.42 million liters/day. This type of runoff is considered **Probable** for the Mount Sutro project since rain sufficient to cause runoff is anticipated during the latter portion of the June 1st–December 1st application season specified in Mount Sutro herbicide application guidelines in Section 2.5. The equation for calculating the concentration of herbicide in water for peak runoff is shown below.

$$\text{Concentration (mg/L)} = \begin{pmatrix}\text{application}\\ \text{rate (lb/acre)}\end{pmatrix} \times \begin{pmatrix}\text{water contamination}\\ \text{rate (mg/L per lb/acre)}\end{pmatrix}$$

The proportion of the chemical that runs off from an application site is chemical-specific and depends on water solubility and $K_{oc}$. Water contamination rates were derived by the USFS and are given in units of

$$\frac{\text{mg chemical per L water}}{\text{pound chemical applied per acre treated}}$$

Values used for water contamination rates are provided in the chemical-specific chapters of this document. Simulations are described for clay, loam, and sand at rainfall rates ranging from 5–50 inches per year. We selected runoff rates for 25 inches per year, the closest match to San Francisco's average rainfall.

### *2.5.2.G Long-term Runoff Based on USFS/SERA Water Contamination Rates*

The chronic scenario developed by the USFS (termed "long-term runoff) provides an estimate of runoff after smaller rainfall events that occur approximately every 10 days. The USFS method provides a water contamination rate derived from the annual average concentration in a million liter water body directly adjacent to a 10-acre application site. At the Mount Sutro site, rain may occur soon after an October or November application. The first rains of the season typically do not cause runoff because the water is mostly absorbed by the dry soil. It is only later in the rainy season that a runoff event is likely to occur. Heavy rain falling on saturated soils results in runoff of the fraction of herbicide that did not degrade over the interim dry season. Long-term runoff is considered to be **Probable**.

Because the proposed application guidelines would require herbicides to be applied between June 1 and December 1, some treatment would occur before the rainy season. To account for early treatment, a decay term was added to the model to account for pesticide degradation

between the application and the beginning of the rainy season. A range of half-lives for each chemical was used to obtain Lower, Central, and Upper estimates for different soil and temperature conditions.

For treatment that occurs before heavy rains begin, values obtained may be overestimates of water contamination because soil saturation and subsequent runoff does not typically occur until November or December in Northern California. Earlier treatment would provide additional time for the chemical to degrade before runoff occurs. The worksheets also do not account for the use of buffer zones in which no herbicide would be applied (discussed in UCSF Sutro Forest Vegetation Management Guidelines, Section 2.5.1.A above).

The equation used to calculate long-term runoff concentrations to Woodland Creek is shown below.

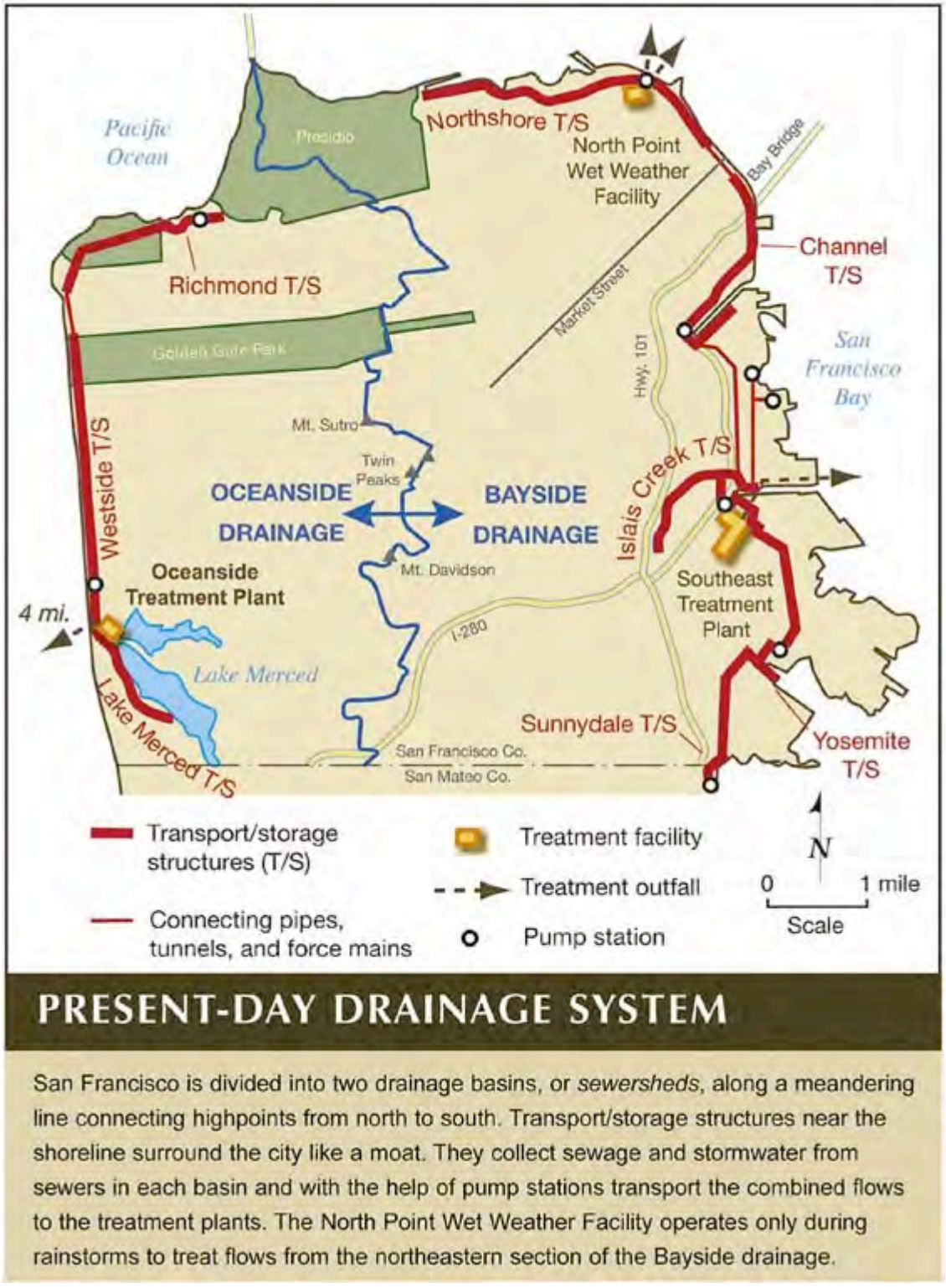
$$\text{Concentration (mg/L)} = \begin{pmatrix}\text{application}\\ \text{rate (lb/acre)}\end{pmatrix} \times \begin{pmatrix}\text{water contamination}\\ \text{rate (mg/l per lb/acre)}\end{pmatrix} \times \begin{pmatrix}\text{fraction remaining}\\ \text{after chemical decay}\\ e^{-\ln(2)\times t/\text{half-life}}\end{pmatrix}$$

Once the herbicide is in the creek, it is diluted by further runoff and moves out of the local area as it runs downhill. The herbicide is typically not replenished by future rain events because most is washed off with the first large rain event, thus, long-term exposure is unlikely. Field studies measuring herbicide water contamination over time often show this pattern of intensive runoff from a heavy storm; future storms do not contribute substantially to additional herbicide runoff. (See the environmental fate sections of the report for each of the herbicides—Sections 3.3 and 4.3—for more details.)

Drinking water contamination from the heavy-runoff scenario would not be a typical "lifetime" chronic exposure scenario, since there is no continuing long-term contamination of the water. Instead of the typical 70-year lifetime period of "chronic exposure," that is used for comparison to a chronic RfD, a more accurate representation of exposure for this situation would be "short-term" exposure periods of several days to several weeks. In EPA's recent risk assessments, they often develop a short-term RfD for these kinds of exposures; however, no short-term RfDs have been developed for oral exposures to either glyphosate or triclopyr, the herbicides proposed for use in the Mount Sutro project. In the absence of an established value for a short-term RfD, the chronic RfD is used for comparison for this type of short-term exposure to herbicides in water.

#### *2.5.2.H Short-term Runoff to Wastewater Treatment Plants*

We estimated concentrations of herbicide that could occur at the two wastewater treatment plants (WWTPs) in San Francisco that receive runoff from Mount Sutro: the Oceanside plant on the West side of the city, which flows to the Pacific Ocean, and the Southeast plant on the east side of the city, which flows to San Francisco Bay. Figure 2-7 shows the watershed boundaries and which WWTP receives the drainage from each. After draining from Mount Sutro, the runoff combines with drainage water from the rest of the city, resulting in dilution of any herbicide present. The capacities of the Oceanside and Southeast Wastewater Treatment Plants represent the maximum daily volume handled by each plant and are used as the final volumes into which the herbicide is diluted.




## PRESENT-DAY DRAINAGE SYSTEM

San Francisco is divided into two drainage basins, or *sewersheds*, along a meandering line connecting highpoints from north to south. Transport/storage structures near the shoreline surround the city like a moat. They collect sewage and stormwater from sewers in each basin and with the help of pump stations transport the combined flows to the treatment plants. The North Point Wet Weather Facility operates only during rainstorms to treat flows from the northeastern section of the Bayside drainage.

**Figure 2-7:** The Mount Sutro watersheds drain to either the San Francisco Bay through the southeast Treatment Plant or the Pacific Ocean through the Oceanside Treatment Plant. *Data Source:* Reference 82.

Concentration estimates were based on the number of acres treated on Mount Sutro, the herbicide application rate, the estimated herbicide loss as a proportion of the application rate ("runoff rate"), the wet-weather capacity at each WWTP and the size of the storm event. We made certain assumptions regarding these variables, which are discussed below. We varied the number of acres treated and the herbicide runoff rate estimated independently for each herbicide to calculate Upper, Central and Lower estimates of herbicide concentration in storm water as it leaves each WWTP, using the equation below.

$$\text{Herbicide concentration } \left(\frac{\text{mg}}{\text{L}}\right) = \frac{\text{Acres treated} \times \text{Application rate } \left(\frac{\text{lbs}}{\text{acre}}\right) \times 1000\frac{\text{mg}}{\text{kg}} \times \text{Runoff rate (\%)}}{\left(2.2\frac{\text{lb}}{\text{kg}}\right) \times \text{WWTP Capacity, wet weather day (L)}}$$

It should be noted that concentrations calculated in this manner will be higher than those at the outfall of each WWTP, since receiving water will dilute the herbicide further.

**Acres treated assumptions:** The number of acres of the Mount Sutro Reserve treated with herbicides will vary depending on the year of the project and the extent of re-sprout treatments necessary. Therefore, we developed risk assessments for a range of scenarios that covered several possible combinations of acres treated and application rate. These are outlined in detail in Section 2.5.1.B). The lowest-concentration scenario involves one acre treated that would flow to the Oceanside WWTP (Demonstration Project 1, South Ridge Area) and two acres treated that would flow to the Southeast WWTP (Demonstration Project 4, East Bowl Corridor) in the event of a storm sufficient to cause runoff. The Maximum treatment scenario is one in which all acres that drain to a particular WWTP are treated immediately prior to a storm sufficient to cause runoff. Based on topography, we assume: 1) twelve out of the 62.7 acres in the Reserve will not be treated because of steepness and inaccessibility, and 2) these 12 acres are equally distributed between watersheds. With these constraints, a maximum of 9.3 treated acres from five watersheds on the eastern side of the Reserve can flow to the Southeast WWTP and runoff from a maximum of 38.7 acres from eight watersheds on the western side of the Reserve can flow to the Southeast WWTP.[84] We also developed Half-treatment and Quarter-treatment scenarios, as described in Section 2.5.1.B. For Demonstration Project #4, two acres out of 7.08 acres in the Woodland Creek watershed is assumed to be treated.

**Runoff rate assumptions:** Predicted water contamination rates for glyphosate runoff to the Oceanside and Southeast WWTPs were estimated using USFS/SERA herbicide runoff rates from GLEAMS modeling. Runoff is variable, depending on climate and soil type, with the USFS/SERA method providing a range of site conditions to choose from. According to the 2001 Mount Sutro Open Space Management Plan, sandy loam soils predominate on the Reserve:[83]

> *In general, soils on Mount Sutro are thin, sandy material. The soil complex is mapped as Candlestick fine sandy loam—Kron sandy loam—Buriburi gravelly loam, on 30 to 75% slopes (SCS 1991). The constituent soil types of this complex are likely to occupy different areas. The Candlestick fine sandy loams are usually from 20 to 40 inches thick over bedrock, whereas the Buriburi gravelly loam and the Kron sandy loam are usually from 10 to 40 inches thick over bedrock. Many slopes have less than six inches of soil depth.*

San Francisco's climate is dry and temperate from approximately May through September, with little or no rainfall runoff in that time period. During the rainy season from October through April, the climate is best described as wet and cool. Since runoff only occurs during this time window, estimated herbicide loss from runoff as a fraction of the application rate was evaluated for "wet and cool" site conditions and loam soils for each herbicide.

**Runoff timing assumptions:** Runoff occurs over a period of time bounded by the moment when soils are saturated and the moment when all excess rainwater has drained from the slope. This period of time can last between fifteen minutes and twelve hours after the large (3.3 inches of rain), 24-hour storm modeled by Clearwater Hydrology for the thirteen watersheds of Mount Sutro (Figure 2-4).[84] Within the runoff period, the amount of herbicide removed via runoff will increase according to the hydrologic profile of the stream, reach a maximum, then decrease to base flow conditions. We employed a single, average herbicide runoff rate throughout the runoff event that provides an average concentration for a 24-hour period. It is important to note that this average runoff rate will underestimate the peak herbicide concentrations, and overestimate herbicide concentrations in the remainder of the runoff cycle.

**Wastewater treatment plant capacity assumptions:** Because the half-lives of both herbicides are much longer than 24 hours, we made the assumption that no herbicide is degraded within the wastewater treatment plants. Additionally, the peak water contamination value also assumes a volume of storm water into which the herbicide runoff is mixed. We based our calculations on a storm that creates enough storm water runoff to meet the "wet weather" threshold at each WWTP: 43 million gallons per day (MGD) at Oceanside or 110 MGD at Southeast.[85] This is a conservative assumption because the maximum capacity for each plant is larger than the wet weather threshold capacity: 150 MGD and 250 MGD, respectively. A storm large enough to bring the plants to capacity would actually dilute the concentration of herbicide to lower concentrations than would a lesser storm.

### 2.5.3 Human Exposure Scenarios

Using the latest version of the USFS/SERA worksheets,[87] we developed exposure assessments for both workers and members of the general public for the pesticide treatments proposed for Mount Sutro. Applicator exposure is derived from actual exposure monitoring data for glyphosate and triclopyr. Exposures for the general public are estimated based on assumptions regarding how the public may come into direct contact with pesticides in or near treated areas.

Exposure estimates are in units of mg chemical per kg body weight to allow for direct comparison to Reference Doses (RfDs). Two types of worker exposure assessments are considered: general and accidental/incidental. The two types of exposure scenarios developed for the general public include acute exposure and longer-term or chronic exposure.

All of the acute exposure scenarios are primarily accidental and assume that an individual is exposed to the compound either during or shortly after its application. Some of these scenarios should be regarded as extreme and **Highly Improbable**. Specific scenarios were developed for workers for spills onto hands or legs, and for the general public for consumption of drinking water contaminated by a spill into Woodland Creek and dermal contact with treated stumps and grasses. Human scenarios for consumption of contaminated fish were not considered in this risk

assessment, since fish are not found in the seasonal Woodland Creek. Human consumption of contaminated blackberries was not considered because all fruit-bearing canes will be cut prior to application of herbicides to the cut-stumps. No fruit from re-sprouted blackberry plants would be present in the first year after treatment, since blackberry canes do not bear fruit in their first year, and UCSF intends to treat re-sprouts in the year after treatment, thus, this exposure scenario is eliminated. The general form of the equation for calculating exposure is:

$$\text{Dose} = \frac{\left(\begin{matrix}\text{Amount of chemical}\\ \text{to which receptor}\\ \text{is exposed}\end{matrix}\right) \times \left(\begin{matrix}\text{Environmental}\\ \text{concentration}\\ \text{of chemical}\end{matrix}\right) \times \left(\begin{matrix}\text{Fraction of}\\ \text{chemical degraded}\\ \text{(if applicable)}\end{matrix}\right) \times \left(\begin{matrix}\text{Absorption rate}\\ \text{(if applicable)}\end{matrix}\right)}{\text{Organism body weight}}$$

The specific equations for the different scenarios considered are presented below.

**Demonstration Projects and Human Exposure Scenarios:** Risk estimates are generally calculated as per-day values. As a result, estimated doses for **workers** are lower for Demonstration Projects 1 and 4 compared to the Main Project because less time is required to treat just one acre, perhaps less than a day. Since the doses and Hazard Quotients presented in tables below are per day worked, however, the values in those tables apply to the Demonstration Projects as well. If a Demonstration Project is treated in less than a full work day (assumed to be 6-8 hours), exposure would be proportionately lower. Risks of exposure for the **general public** are considered to be lower for Demonstration Projects 1 and 4 compared to the project itself because the Demonstration Projects occupy a small fraction of the overall Mount Sutro reserve—one and two acres, respectively—thus, recreational users would be less likely to encounter the Demonstration Projects than a larger treated area as part of the Main Project. However, any individual venturing into the Demonstration Projects would face exposure equivalent to any treated portion of the Reserve.

#### *2.5.3.A Worker Exposure*

Two types of worker exposure assessments are considered: general and accidental. General exposures occur from ordinary chemical handling and contact with treated surfaces and spray drift during the application. Dermal exposure is the most likely type of "general exposure" for herbicide applicators.[86a, b] Accidental exposure scenarios involve spills and splashes that could occur during application and result in high exposures over short time periods. Workers are assumed to be men weighing 70 kg. The Lower, Central and Upper exposure estimates assume Mount Sutro applicators will work six, seven or eight hours per day.

**General worker exposures, foliar applications:** Exposure estimates were performed for directed foliar applications using the USFS/SERA worksheets.[87] This analysis assumes that the sprayer is carried with a backpack and that applicators treat brush up to shoulder height; arms, hands, or face might contact treated vegetation. USFS/SERA assumes that foliar workers treat from 0.25–1 acre per hour, with a central estimate of 0.5 acres per hour.

**General worker exposures, cut-stump applications:** General exposure for the cut-stump worker exposure scenario was not specifically addressed in the 2011 USFS worksheets. Pesticide Research Institute added a spreadsheet for general worker exposure for cut-stump techniques,

utilizing the UC Berkeley report to obtain an empirical value for acres treated per hour.[10] The authors noted:

> *The 1,800 trees were felled in 3 days, consisting of approximately 15 working hours. This work pace allowed for the felling of approximately 120 trees per hour, an astounding production rate. The herbicide treatment was provided by UC staff, which was pressed to treat 2 cut stumps per minute within 5 minutes after felling.*

On the Mount Sutro Reserve, the average number of trees to be removed per acre is 609.[88] At a rate of two cut stumps per minute, 0.2 acres can be treated each hour. This value was used as the Upper estimate. The Central value was estimated at 75% of this rate or 0.15 acres per hour, and the Lower value was estimated at 50% of this rate or 0.1 acres per hour. In other words, an average acre is expected to require at least five hours, but no more than 10 hours, to treat using the cut-stump method. The Lower, Central and Upper exposure estimates shown in Table 3-14 assume Mount Sutro cut-stump and foliar applicators will work six, seven or eight hours per day. The field concentrations of the solutions to be used for cut-stump treatments are proposed to be dilutions of 5, 20 and 50 percent of the pure product, which contains 4 lbs a.e./gal for either Aquamaster (glyphosate) or Garlon 4 Ultra (triclopyr BEE).

Changes also had to be made to the dermal absorption rate (permeability) of the chemical, or Absorbed Dose Rate (ADR) used in the calculation, compared to that used for foliar sprays. The ADR is a measure of how much of the chemical is absorbed through the skin as a function of amount of pesticide handled. The dermal absorption rate increases proportionally with the concentration of the solution,[12] thus exposure to the more concentrated cut-stump solutions will increase the absorbed dose in proportion to the concentration of the solution.

For **foliar** applications of glyphosate and triclopyr BEE by backpack sprayer, USFS/SERA used empirical worker exposure studies to determine a realistic rate of pesticide absorption per kg handled by a worker per day. The range of the ADR was determined to be 0.003 to 0.01 mg/kg of body weight per pound of active ingredient applied. The available field studies were conducted using a range of field concentrations from 2.3–8 percent solutions of Roundup™, with biomonitoring providing data on the amount of pesticide absorbed by workers over the course of a workday (see Biomonitoring sections in the herbicide-specific chapters).[89 a-f]

To estimate exposures from **cut-stump** applications using a spray applicator, we adapted the method from the foliar exposure assessment. The product concentrations in the foliar sprays of glyphosate used in the biomonitoring studies ranged from 2.3–8 percent, comparable to the lowest proposed concentration of cut-stump solution at five percent. Because of the similar concentrations, we used the *Central* ADR estimate from the *foliar* application scenario of 0.003 mg/kg body weight per lb/acre of active ingredient as an estimate of the *Lower* ADR for *cut-stump* applications with the 5% solution of herbicide product. For the Upper and Central ADR estimates, we multiplied the Lower ADR times the ratio of the Lower ADR concentration (5% solution) to concentrations for the Central ADR (20% solution) or the Upper ADR (a 50% solution), as shown below:

$$\text{Central cut stump ADR}\left(\frac{\text{mg}}{\text{kg}}\text{per}\frac{\text{lb}}{\text{acre}}\right) = \text{Lower ADR} \times \left(\frac{20\%}{5\%}\right) = 0.003 \times 4 = 0.012\left(\frac{\text{mg}}{\text{kg}}\text{per}\frac{\text{lb}}{\text{acre}}\right)$$

$$\text{Upper cut stump ADR}\left(\frac{\text{mg}}{\text{kg}}\text{per}\frac{\text{lb}}{\text{acre}}\right) = \text{Lower ADR} \times \left(\frac{50\%}{5\%}\right) = 0.003 \times 10 = 0.03\left(\frac{\text{mg}}{\text{kg}}\text{per}\frac{\text{lb}}{\text{acre}}\right)$$

Table 2-13 provides the absorbed dose rates used for foliar and cut-stump applications.

With this information, we can then estimate the absorbed dose using the equation describing general worker exposure for both foliar and cut-stump applications using Equation S1.

$$\text{Dose (mg/kg)} = \begin{pmatrix}\text{hours}\\ \text{worked}\\ \text{per day}\end{pmatrix} \times \begin{pmatrix}\text{acres treated}\\ \text{per hour}\end{pmatrix} \times \begin{pmatrix}\text{application}\\ \text{rate (lb/acre)}\end{pmatrix} \times \begin{pmatrix}\text{absorbed dose rate}\\ \text{(mg / kg bw per lb/day}\end{pmatrix} \qquad \text{S1}$$

**Table 2-14: Typical Absorbed Doses For Various Application Methods**

| Application Method | Absorbed Dose Rate Estimates (in mg per kg body weight per pound handled per day) | | |
|---|---|---|---|
| | **Lower** | **Central** | **Upper** |
| **Glyphosate IPA** | | | |
| Backpack spray | 0.0003 | 0.003 | 0.01 |
| Cut-stump treatment | 0.003 | 0.012 | 0.03 |
| **Triclopyr BEE** | | | |
| Backpack spray | 0.00086 | 0.0058 | 0.039 |
| Cut-stump treatment | 0.0058 | 0.023 | 0.058 |

*Data source:* USFS Worksheet A02[87] and PRI adaptation of USFS worksheets for cut-stump treatments.

The use of the method described above for estimating general exposures for workers conducting cut-stump applications is best used for scenarios in which workers use spray application techniques to treat cut stumps/stems; experimental data indicated that applications using paint brushes, wicks, squirt bottles or injection techniques result in lower general exposures, as described below.

Lavy *et al.* (1987)[90] compared general exposures for workers using different application techniques and with different safety measures. In this study, four crews of 20 workers in each crew applied 2,4-D, dichlorprop or picloram using a backpack sprayer, injection bar, Hypohatchet, or a hack-and-squirt method (comparable to cut stump techniques). Total urine output was measured under two sets of conditions: 1) Normal work habits and no special clothing, and 2) Workers asked to "take all feasible precautions to prevent herbicide exposure and to wash immediately if they come into contact with the chemical," and issued new leather gloves and boots prior to working. On average, backpack spray workers were exposed to approximately 10 times more herbicide than workers using injection bar or hack-and-squirt application techniques. The use of greater precautions led to significantly lower exposures for all applicators except backpack spray workers. This study indicates that if all cut-stump work is done with cut-stump techniques using paintbrush, wick or squirt bottle, exposures can be minimized. However, if a backpack sprayer is used to apply herbicide to cut stumps, exposures

can reasonably be anticipated to be much higher. In the Mount Sutro risk assessment, we assumed that spray applicators could be used for treating cut-stumps/stems, especially for brush like blackberry and poison oak, since it would be difficult and time-consuming to paint every stem by hand; however, if only a brush or wick applicator were used, risks could be reduced substantially, by approximately a factor of 10.

### Accidental Exposures

For systemic absorption from accidental exposures, our analysis focuses on dermal exposure from accidental spills or sprays. There is no method for quantifying a systemic dose by ocular exposure, but it is likely to be low because of the low surface area of the eyes. While splashes into the eyes may not result in significant systemic exposure, any herbicide that is an irritant and/or corrosive will cause local acute effects. Maintaining eye-wash and hand-washing supplies at ready access in each vehicle is important for limiting acute effects from local exposures.

Four accidental systemic exposure scenarios were developed to model the upper limit of worker exposures:

1. Wearing contaminated gloves for one minute (**Probable**)
2. Wearing contaminated gloves for 60 minutes (**Improbable**)
3. Spilling or spraying the chemical on a worker's hands, left for one hour (**Improbable**)
4. Spilling or spraying the chemical on a worker's lower legs, left for one hour (**Improbable**).

Exposure scenarios for workers wearing gloves are based on the assumption that wearing contaminated gloves is similar to immersing hands in a solution of the herbicide. These dermal absorption estimates are based on a "zero-order" dermal permeability rate, which assumes an unlimited amount of pesticide available for absorption through the skin. Equation S3 describes the exposure calculation.

$$\text{Dose (mg/kg)} = \frac{\left(\begin{array}{c}\text{dermal}\\ \text{permeability}\\ \text{(cm/hr)}\end{array}\right) \times \left(\begin{array}{c}\text{time}\\ \text{(hr)}\end{array}\right) \times \left(\begin{array}{c}\text{chemical}\\ \text{concentration}\\ \text{(mg/L)}\end{array}\right) \times \left(\begin{array}{c}\text{surface}\\ \text{area (cm}^2\text{)}\end{array}\right) \times \left(\begin{array}{c}\text{unit conversion:}\\ \text{0.001 L/cm}^3\end{array}\right)}{\text{organism body weight (kg)}} \qquad \text{(S3)}$$

Surface areas for exposed parts of the body have been determined experimentally by US EPA. Measurements are available for adult males, adult females and children as a function of age.[91a,b] See Table 2-15.

For direct spray or spill scenarios, a "first order" dermal exposure model is used. It is assumed that a solution of the chemical is spilled on and adheres to a given skin surface area, with no additional chemical replenishment. The absorbed dose is then calculated as the product of the amount of the chemical on the surface of the skin and the fraction of the adhered chemical that enters the body.

**Table 2-15: Dermal Exposure Parameters**

| Exposed Area | Receptor | Mean Surface Area ($cm^2$) |
|---|---|---|
| Hands | Male worker | 840 |
| Lower legs[a] | Male worker | 2,070 |
| Lower legs and feet | Adult female | 2,915 |
| Sitting surface (underside of thighs), wearing shorts | Adult female | 1,213 |
| | Child | 325 |
| Whole body | Child | 6,030 |

[a] The surface area of feet is omitted for workers because workers are assumed not to walk barefoot, whereas a hiker might walk or wade barefoot or with sandals. *Data source:* Reference 91.

The fraction of the chemical that enters the body is a function of the first-order dermal absorption rate for the particular herbicide and the duration of exposure. The longer the chemical remains on the skin, the larger the fraction of chemical absorbed. The exposure calculation is given in Equation S4 below.

$$\text{Dose (mg/kg)} = \frac{\left(\begin{array}{c}\text{application}\\ \text{concentration,}\\ \text{(mg/L)}\end{array}\right) \times \left(\begin{array}{c}\text{fraction}\\ \text{adhering to}\\ \text{skin (mL/cm}^2\text{)}\end{array}\right) \times \left(\begin{array}{c}\text{surface area}\\ \text{sprayed (cm}^2\text{)}\end{array}\right) \times \left(\begin{array}{c}\text{fraction absorbed:}\\ 1 - e^{-(\text{dermal absorption rate})t}\end{array}\right) \times \left(\begin{array}{c}\text{conversion:}\\ \text{0.001 L/mL}\end{array}\right)}{\text{organism body weight, (kg)}} \quad \textbf{(S4)}$$

Human dermal exposure is a function of the dermal absorption rate (permeability) of the chemical. Two dermal absorption rates are used in the exposure estimates: 1) a zero-order absorption rate (in units of cm/hr) which is used when the skin is assumed to be submerged in the chemical, and 2) a first-order absorption rate ($hr^{-1}$) which is used when it is assumed that a finite amount of the chemical is on the skin that decreases over time. Using the EPA guidelines for dermal absorption rates,[92] SERA estimated dermal absorption rates, $K_p$, based on $K_{ow}$ and molecular weight (MW):

**Zero-Order:** $$\log K_p = (0.71 \times \log K_{ow}) - (0.0061 \times MW) - 2.72$$

**First-Order:** $$\log K_p = (0.233 \times \log K_{ow}) - (0.00566 \times MW) - 1.50$$

Calculated dermal absorption rates were used in exposure calculations when there were no empirically measured dermal permeability rates. Where data were available (for the first-order absorption rates for glyphosate and triclopyr BEE), the USFS used empirically determined dermal absorption rates. For the direct spray and accidental worker exposure scenarios, only the Central value of $K_p$ was used in the calculation of the Central, Upper and Lower exposure scenarios, to allow for a more accurate comparison of dose between a direct spray with foliar and cut-stump treatment solutions.[93]

**Inhalation exposures:** Inhalation worker exposure was not calculated because glyphosate and triclopyr are not highly volatile. Inhalation exposure due to spray drift for backpack applicators is accounted for by the "general" exposure estimate for this type of work (see above).

#### *2.5.3.B Exposures to the General Public*

Both acute and chronic exposure scenarios were evaluated for the general public. The general strategy for these exposure estimates is to present at least one scenario that represents a **Highly Improbable**, worst-case exposure event, and one or more scenarios that represent a more probable event. If the worst-case event still has a hazard quotient below one, then more probable exposures will have hazard quotients much less than one. The body weights used for the general public are 70 kg for men, 64 kg for women and 13.3 kg for children.

For acute exposure, it is assumed that an individual is exposed to the herbicide either during or shortly after its application. Specific scenarios are developed for direct spray, dermal contact with contaminated vegetation, and consumption of contaminated water.

The longer-term or chronic exposure scenarios parallel the acute exposure scenarios for the consumption of contaminated water, but are based on estimated levels of exposure for longer periods after application and account for dissipation and herbicide breakdown over time.

**Exposure from Direct Spray:** Direct spray of a member of the general public for ground applications are modeled in a manner similar to accidental spills for workers. It is assumed that the individual is sprayed with a solution containing the herbicide, that a fraction of the compound remains on the skin, and that the chemical is absorbed by first-order kinetics. The calculation for this scenario is described by Equation S4 above. The dermal absorption parameters are chemical-specific and are given in the exposure assessment section for each chemical. Table 2-15 above gives surface area values used in the calculation for men, women and children.

For direct spray, the worst-case scenario during a ground application is that a naked child is sprayed over 100% of his/her surface area. This is a **Highly Improbable** exposure scenario that is not meant to simulate a likely event. Rather, this scenario, involving a vulnerable individual with a high surface area to weight ratio, represents the upper limits of exposure from direct spray. All plausible real-life exposures will be lower. An additional, more plausible scenario is included for a woman who is accidentally sprayed over the feet and legs. Exposure estimates from sprays with both cut-stump and foliar application solutions are included.

**Dermal Exposure From Contaminated Vegetation:** For foliar applications, it is assumed that the herbicide is sprayed at a given application rate and that an individual comes in contact with dry sprayed vegetation or other contaminated surfaces at some time soon after the spray operation. Under the conditions of application where large leafy species are cut down to stumps prior to treatment, such as for the trees and brush in the Mount Sutro Reserve, these types of exposures are considered to be **Improbable**. The probability of exposure is **Possible** for contact with treated foliage, such as *Ehrharta* grasses or treated re-sprouts.

For these exposure scenarios, dislodgeable foliar residue and the rate of transfer from the contaminated vegetation to the surface of the skin are available from empirical studies.[94]

Estimates of skin surface area used in the calculation are given in Table 2-13. The calculation for this dermal exposure scenario is shown in Equation S5,

$$\text{Dose (mg/kg)} = \frac{\binom{\text{surface area}}{(\text{cm}^2)} \times \binom{\text{transfer rate}}{(\text{mg/hr cm}^2)} \times \binom{\text{contact time}}{(\text{hr})} \times \binom{\text{fraction that drifts}}{} \times \binom{\text{fraction absorbed}}{1-e^{-K_a \times t}}}{\text{organism body weight (kg)}} \quad \text{(S5)}$$

where Transfer Rate = 1.12 x [(proportion dislodgeable) x (application rate (kg/ha)]$^{1.09}$, $K_a$ is the first-order dermal absorption rate per hour and t is the exposure time prior to washing the skin, assumed to be 24 hours. When the fraction that drifts is set to one, the scenario is for a direct spray of vegetation. Lowering this value would result in estimates for contamination by offsite spray drift.

**Dermal Exposure From Cut Stumps:** For cut-stump applications, it is assumed that the herbicide is applied at an application rate determined by the amount of herbicide applied per stump surface area, and that an individual wearing shorts sits on the stump at some time soon after it is treated, thereby exposing bare thighs to the treated surface.

Several studies of cut-stump treatments with $^{14}$C-radiolabeled herbicides are available that indicate that herbicide absorption and translocation to other parts of the plant can occur relatively rapidly, reducing the amount of herbicide available for transfer to the skin.

Wahlers *et al.* conducted cut-stem trials of triclopyr and clopyralid transport in dogfennel plants.[95] The authors noted that more than 73 percent of applied $^{14}$C-triclopyr was absorbed immediately into the plant, as determined by submerging the upper 1 cm of stem in water, then in 0.1% ammonium hydroxide solution within 2 seconds and measuring the radioactivity in the extracts. They repeated this process for different groups of plants at 1, 10 and 60 min after treatment in order to follow the course of the absorption over time, with uptake measured at 90 percent by one hour after treatment. The radiolabeled compounds appeared in the roots of the plant as soon as 12 hours after treatment, and by 48 hours, 5–7 percent of the $^{14}$C label was found in the roots and 7–10 percent had been exuded from the roots. The greatest fraction of the radioactivity remained in the upper stems, but was unavailable for extraction. The authors noted

> *We hypothesize that when herbicide is introduced while cutting the stem, xylem cavitation occurs and pulls the compound inward. This is a likely explanation for the 70 to 80% absorption of triclopyr and clopyralid that occurred immediately after stem cutting in our studies. After xylem flow halts, herbicide diffuses laterally to sieve elements and is likely translocated basipetally via the phloem, although some diffusion through the stem cortical and pith tissue may also occur. From this standpoint, it may be important or necessary to introduce herbicide into the wound at the same time the cut is made to maximize uptake due to cavitation.*

In another study, True and Richardson evaluated the absorption and translocation of $^{14}$C-radiolabeled glyphosate in beach vitex (a woody shrub) for both cut-stem and foliar application methods.[96] Plants were treated with a 50:50 mix of $^{14}$C-labeled glyphosate solution and methylated seed oil and harvested at 6, 24, 48, 92, and 196 hours after treatment to determine the

extent of translocation. For the cut-stem treatments, all absorption and translocation occurred within the first six hours after treatment. At the end of the study, 87.1% of the applied herbicide recovered remained in the stump, 4.9% translocated to the first root section, and only minimal amounts were translocated to root segments further away from the stump. Unfortunately, the authors did not directly measure the amounts available for transfer from the treated surface.

These studies are valuable for predicting exposures from cut-stump applications, but it is likely that absorption rates and absolute amounts absorbed will vary with the species being treated, the developmental stage of the plant, the adjuvant used in the mixture, the concentration of the herbicide in the applied solution, the temperature, the time between cutting and treating the stump, the form of the herbicide (acid, salt or ester), and the season of application.

For the cut-stump exposure scenarios in this risk assessment, the dislodgeable residue was estimated based on the $^{14}C$ labeling studies of translocation discussed above. Because of the small number of studies and the large number of variables that could potentially affect herbicide uptake and translocation, we used Lower and Upper estimates of dislodgeable residue of five percent and 30 percent, respectively, to cover a broad range of possibilities, with a Central estimate of 10 percent based on the available empirical data.

Estimates of skin surface area used in the calculation are given in Table 2-13. The calculation for this dermal exposure scenario is shown in Equation S6,

$$\text{Dose (mg/kg)} = \frac{\left(\begin{matrix}\text{surface}\\ \text{area}\\ (\text{cm}^2)\end{matrix}\right)\times\left(\begin{matrix}\text{transfer}\\ \text{rate}\\ (\text{mg/hr cm}^2)\end{matrix}\right)\times\left(\begin{matrix}\text{contact}\\ \text{time}\\ (\text{hr})\end{matrix}\right)\times\left(\begin{matrix}\text{fraction absorbed}\\ 1-e^{-K_a\times t}\end{matrix}\right)}{\text{organism body weight (kg)}} \qquad \text{(S6)}$$

where Transfer Rate = 1.12 x [(proportion dislodgeable) x (application rate (kg/ha)]$^{1.09}$, $K_a$ is the first-order dermal absorption rate per hour and t is the exposure time prior to washing the skin, assumed to be 24 hours. The proportion dislodgeable is one minus the proportion of herbicide absorbed by the stump.

**Exposure from Drinking Contaminated Water:** Water contamination scenarios are described in Section 2.5.2 above. The accidental spill scenario assumes that a young child (or a woman of childbearing age for triclopyr) consumes contaminated water from a small pond or puddle shortly after an accidental spill of one gallon of concentrated or diluted herbicide and is considered **Highly Improbable**. Because this scenario is based on the assumption that exposure occurs shortly after the spill, no dissipation or degradation of the herbicide is considered. The concentration in the water depends on the amount of herbicide spilled, the size of the water body into which it is spilled, and the amount of contaminated water that is consumed. Table 2-16 presents average water consumption rates for adults and children used in this calculation. The exposure calculation for this scenario is shown in Equation S7 below.

$$\text{Dose (mg/kg - day)} = \frac{\left(\begin{matrix}\text{water body herbicide}\\ \text{concentration (mg/L)}\end{matrix}\right)\times\left(\begin{matrix}\text{amount of}\\ \text{water consumed (L/day)}\end{matrix}\right)}{\text{organism body weight (kg)}} \qquad \text{(S7)}$$

**Table 2-16: Water Consumption Parameters**

| Daily Water intake (Liters) | Low-End Estimate | Central Estimate | High-End Estimate |
|---|---|---|---|
| Adult | 1.4 | 2.0 | 2.4 |
| Child | 0.61 | 1.0 | 1.5 |

*Data Source:* From USFS Worksheet A03, reference 87.

#### *2.5.3.C Aggregate Exposures*

Aggregate exposure is the sum of exposures from different pathways. For example, a worker may brush up against wet foliage during applications multiple times during the day and may also be directly sprayed. Aggregate exposure for workers is estimated by summing multiple exposure events during an eight-hour day. These are **Probable** and are discussed in the text for each herbicide. Such aggregate exposure scenarios for the general public are **Highly Improbable** in the context of Mount Sutro and were not evaluated.

### 2.5.4 Terrestrial Wildlife Exposure Scenarios

Terrestrial animals can be exposed to an applied herbicide through ingestion of contaminated media (vegetation, prey species, water, or grooming activities) or dermal contact with treated vegetation. Dermal contact from direct spray, spray drift and contact with contaminated vegetation are considered because directed, spot spraying may be performed; broadcast spraying will not be conducted. We express estimated wildlife doses in the same units as available TRVs to permit easy comparison between estimated exposure and TRVs. Ingested doses are expressed as mg of chemical per kg of body weight and abbreviated as mg/kg bw. Dermal exposures in milligrams of chemical that contacts a square centimeter of skin are converted to absorbed dose—the fraction of the exposure actually absorbed by the animal. The dermal permeability parameters convert exposure to absorbed dose.

The same basic equation is used for estimating wildlife exposures as for human exposures:

$$\text{Dose} = \frac{\begin{pmatrix}\text{amount of exposure to}\\ \text{contaminated media}\\ \text{e.g. ingestion, dermal}\end{pmatrix} \times \begin{pmatrix}\text{environmental}\\ \text{concentration}\end{pmatrix} \times \begin{pmatrix}\text{fraction of}\\ \text{chemical degraded}\\ \text{(if applicable)}\end{pmatrix} \times \begin{pmatrix}\text{absorption}\\ \text{rate}\\ \text{(if applicable)}\end{pmatrix}}{\text{organism body weight}} \qquad \text{(S8)}$$

The amount of a chemical that an organism is exposed to is the sum of oral, dermal and inhalation exposure. Wildlife inhalation and ocular exposure are not considered by USFS or US EPA, only dermal and oral exposure. Inhalation exposure is unlikely to be a significant contributor to total exposure because no broadcast spraying will occur and glyphosate and triclopyr do not readily volatilize. Ocular exposure is unlikely to contribute substantially to total systemic exposure, because of the small surface area of the eyes, although local acute effects are possible. The calculations, assumptions and uncertainties associated with each calculation are described below.

**Demonstration Projects and Terrestrial Wildlife Exposure Scenarios:** As with risks to the general public, risks to wildlife would be lower after treatment of the two Demonstration Projects compared to treatment of the Reserve as a whole. Because fewer acres would be treated,

the chance of entering the Demonstration Projects would be lower and fewer animals would be exposed. However, animals that venture into the Demonstration Project areas would face exposure equivalent to that in any treated portion of the Reserve.

#### *2.5.4.A Notes on Wildlife Exposure Parameters*

Species-specific parameters for body surface area and food and water intake are essential inputs into the exposure model. These parameters are mostly unavailable, but can be estimated using allometric equations that describe surface area and food and water intake as a function of the species' average body weight.[97] An allometric relationship takes the form:

$$y = aW^x$$

where $W$ is the average weight of the species (in grams), $y$ is the variable to be estimated—for example, surface area (in $m^2$), food intake (in grams/day or kcal/day), or water intake (in L/day). The model parameters $a$ (sometimes called "alpha" in USFS documents) and $x$ (sometimes called "beta") are empirically derived. For most allometric relationships for food intake as a function of body weight, $x$ ranges from approximately 0.65 to 0.75.

**Table 2-17: Food Intake Predicted by Allometric Relationships**

| Animal | | Body Weight (kg) | Allometric Equation | Caloric Intake (kcal/day*) |
|---|---|---|---|---|
| Mammal | Small | 0.02 | 0.621 x (body weight in grams)$^{0.584}$ | 3.36 g/day |
| | Large | 70 | 1.518 x (body weight in grams)$^{0.73}$ | 5,230 |
| Carnivore, | Small | 5 | 1.894 x (body weight in grams)$^{0.7}$ | 736 |
| | Large | 40 | | 3,154 |
| Carnivorous bird | | 0.637 | 1.146 x (body weight in grams)$^{0.749}$ | 203 |
| All birds, | Small | 0.01 | 3.12 x (body weight in grams)$^{0.604}$ | 13 |
| | Large | 4 | | 471 |

*Data source:* Reference 97. (US EPA, 1993)
* Unless indicated otherwise.

**Table 2-18: Water Intake Predicted by Allometric Relationships**

| Animal | | Body Weight (kg) | Allometric Equation | Water Intake (L/day) |
|---|---|---|---|---|
| Mammal | Small | 0.02 | 0.099 x (body weight in kg)$^{0.9}$ | 0.003 |
| | Large | 70 | | 4.5 |
| Bird | Small | 0.01 | 0.059 x (body weight in kg)$^{0.67}$ | 0.003 |
| | Large | 4 | | 0.15 |

*Data source:* Reference 97. (US EPA, 1993)

**Table 2-19: Surface Area Predicted by Allometric Relationships**

| Animal | | Body Weight (kg) | Allometric Equation | Surface Area ($m^2$) |
|---|---|---|---|---|
| Mammal | | 0.02 | 0.11 x (body weight in kg)$^{0.65}$ | 0.0087 |
| Honeybee | | 0.000116 | 0.11 x (body weight in kg)$^{0.65}$ | 0.00026 |
| Bird | Small | 0.01 | 0.11 x (body weight in kg)$^{0.65}$ | 0.0055 |
| | Large | 4.0 | 0.11 x (body weight in kg)$^{0.65}$ | 0.27 |

*Data source:* Reference 97. (US EPA, 1993)

In general, wildlife has higher caloric requirements than humans due to higher activity levels and the need for thermo-regulation in outdoor environments. In the event that this caloric intake rate is an overestimate of a large mammal's needs, the exposure estimate will be *more* protective. The more an animal eats per kilogram of body weight, the higher the potential dose, with very small animals most at risk of high exposure. See Tables 2-17 through 2-19 for representative allometric equations. A larger carnivore weighing 40 kg is included in the analysis (similar to a large coyote) for the sake of completeness; however, the small 5-kg carnivore will have a larger exposure per kilogram of body weight, providing a worst-case scenario.[98]

#### *2.5.4.B Dermal Exposure for Terrestrial Animals*

Three dermal exposure scenarios for direct spray of terrestrial wildlife are presented:

1. One hundred percent absorption of a direct spray to 50 percent of the surface area of a honeybee, as shown in equation S9 below. Converting the TRV from µg/bee to mg/kg uses a conversion factor of 1000 µg/mg assumes that a honeybee weighs 0.000116 kg.

$$Dose\ (mg/kg) = \frac{\left(\frac{application}{rate\ (kg/ha)}\right)\times\left(\frac{Cut-stump}{concentration\ factor}\right)\times\left(\frac{10^3 mg}{kg}\right)\times(0.5\times SA\ (m^2)\times\left(\frac{10^4 m^2}{ha}\right)\times}{organism\ body\ weight\ (kg)} \quad \text{(S9)}$$

2. One hundred percent absorption of a direct spray to 50 percent of the surface area of a small mammal (equation S9).

3. First-order absorption of a direct spray to 50 percent of the surface area of a small mammal (equation S10).

$$Dose\ (mg/kg) = \frac{\left(\frac{application}{rate\ (kg/ha)}\right)\times\left(\frac{Cut-stump}{concentration\ factor}\right)\left(\frac{10^3 mg}{kg}\right)\times(0.5\times SA\ (m^2)\times\left(\frac{10^4 m^2}{ha}\right)\times\left(\frac{fraction\ absorbed}{1-e^{-(derm.abs.rate)\times t}}\right)}{organism\ body\ weight\ (kg)} \quad \text{(S10)}$$

where *t* is the exposure time.

The USFS worksheets as they are currently configured will underestimate these direct-spray exposures to solutions used for cut-stump applications. For most scenarios involving contamination from direct sprays, the USFS/SERA assumption is that a fairly dilute solution of herbicide (typically at 1–10 percent dilution) is evenly applied over each acre treated. This assumption is used because most of the empirical data are given in terms of application rates in pounds per acre. This approach is reasonably valid for foliar application scenarios, but is problematic for cut-stump applications. Cut-stump treatments are targeted, low-volume

applications using a highly concentrated solution. Typically, a plant is cut down to the base of the trunk and the remaining stump is sprayed from close range with highly concentrated solutions, as discussed in Section 2.1.1. Unless careful attention is paid to application concentrations and volumes, local application rates for cut-stump treatments can be much higher than foliar application rates, since the treated area receives a more concentrated solution than for a typical foliar application. If a small mammal or insect intercepts the highly concentrated cut-stump spray, exposures will be much higher than direct spray from a diluted foliar treatment. Fewer small mammals or insects would be affected because the treated area is smaller, but the ones that are hit with a direct spray would be exposed to a concentrated dose. In other words, cut-stump applications are inherently uneven, and the USFS model scenarios are not designed to handle uneven applications.

For the Mount Sutro risk assessment, we modified Equations S9 and S10 to account for the fact that the per-acre application rate is higher for cut-stump/stem solutions with which small mammals and insects might be sprayed. Data from the studies described in Section 2.1.1.C on page 8 indicate that the local application rate around the cut stump/stem area treated using either cut-stump, basal bark or backpack spray methods ranges from three to 200 times greater than backpack spray foliar application rates. The Central, Upper and Lower “cut-stump concentration factor” selected for use in this risk assessment are 50, 200, and 1 and were based on these empirical studies and the approximate differences in concentration between foliar and cut-stump solutions.

Dermal exposure is only modeled for small mammals and insects because they are small enough to be overlooked by herbicide applicators. It is **Improbable** that an applicator would spray a small mammal that does not flee, but it is nearly impossible for an applicator to directly spray a deer or a bird. The extent of dermal contact in a direct spray scenario depends on the application rate, surface area of the organism and the proportion of that surface area sprayed, rate of chemical absorption, and length of time the chemical residue remains on the skin/fur/feathers. In the absence of any data regarding dermal absorption in small mammals, the estimated absorption rate for humans was used. The allometric relationships (described in Section 2.5.4.A above) between body weight and surface area were used to estimate the surface area of the animal (see Table 2-18).[99]

There are uncertainties in calculating doses due to dermal exposure, but the 100% absorption scenario provides an upper bound estimate. The 100% absorption scenario is designed to address ingestion of the chemical through grooming activities. Complete dermal absorption for terrestrial amphibians would also be logical to include considering their permeable skin. However, no toxicity studies for adult amphibians are available for the chemicals in this risk assessment. Therefore, only exposure estimates for tadpoles in aquatic systems are presented.

Actual exposures may be lower than these worst-case scenarios for several reasons. Fur and feathers provide protection against dermal absorption, and organisms may rub or wash chemical residues off of their fur or skin before the residues are absorbed. Dermal absorption rates are chemical-specific and thus are provided in the chapter for each chemical.

**Indirect dermal exposure:** The worst-case scenarios for indirect dermal exposure—scenarios in which wildlife brush against contaminated vegetation—result in substantially lower doses than the direct spray scenario. The volume of liquid capable of adhering to the skin for all chemicals is assumed to be 0.008 mL/cm$^2$. No indirect dermal exposures are calculated in the USFS/SERA worksheets, since the worst case is captured by the direct spray scenario and doses from indirect spray are several orders of magnitude lower. For the same reason, the USFS/SERA worksheets do not consider dermal exposure from spray drift.

#### *2.5.4.C Exposures from Consumption of Contaminated Vegetation or Prey*

The highest estimated exposures for wildlife were from the consumption of contaminated vegetation, and/or prey that has eaten contaminated vegetation. Exposures from these routes were modeled for carnivorous mammals and birds (Equation S11), large herbivorous mammals and birds (Equations S14 and S15), insectivorous small mammals (Equation S14), and other small mammals (Equation S7 and S8, above). Where applicable, acute on-site exposures (Equations S13 and S14) and chronic on and off-site exposures (Equations S13 and S15) are estimated.

Data from one glyphosate study indicate that 100% dermal absorption is likely to be an overestimate, but first-order dermal absorption is a reasonable assumption.[100] The study found that aerial application of 3 lb/acre of glyphosate resulted in measured doses of 1.7 mg/kg for small carnivores. This value is nearly identical to the Upper first-order dermal absorption estimate for a small mammal, but 14–41 times lower than the 100% absorption estimate. The study did not distinguish the main route of exposure for the empirically tested wildlife. It is likely that the dose is from a combination of eating contaminated food, drinking contaminated water and dermal exposure or ingestion exposure from grooming. The calculation assumes that the entire dose was from dermal exposure, which indicates that this may overestimate actual dermal doses. There is still variability in the data. One deer mouse was observed to have been exposed to a dose of 5 mg/kg from all sources. This was the highest dose recorded, with 1.7 mg/kg as the next highest measured dose.

Equation S11 shows the exposure calculation for consumption of contaminated small mammals by carnivorous mammals and birds. Although Equation S11 can be modified to account for spray-drift contamination of prey, a worst-case estimate was assumed, where prey were directly sprayed before being eaten.

$$Dose\ (mg/kg) = \frac{\left(\frac{food\ needs\ (kcal)}{kcal\ in\ wet\ prey\ \left(\frac{kcal}{kg}food\right)}\right) \times \left(application\ rate\ (kg/ha)\right) \times \left(residue\ rate\ (mg/kg\ food\ per\ kg/ha)\right) \times \left(fraction\ of\ diet\ contaminated\right)}{organism\ body\ weight\ (kg)} \quad \text{(S11)}$$

Equation S12 describes acute exposure estimates for consumption of contaminated vegetation by an herbivore. Because most of the Mount Sutro treatments are likely to be spot treatments, the USFS assumption of 100% of the diet consumed at a treated site ("on-site") will overestimate exposures. Instead, we assumed Central, Lower, and Upper estimates of 10%, 30% and 100% of the diet contaminated for acute exposure estimates in this risk assessment.

$$\text{Dose (mg/kg)} = \frac{\dfrac{\left(\begin{array}{c}\text{food needs}\\(\text{kcal})\end{array}\right)}{\left(\begin{array}{c}\text{kcal in dry}\\\text{food}\\(\text{kcal/kg food})\end{array}\right)\times\left(\begin{array}{c}\text{fraction of food}\\\text{that is dry}\\(\text{kg dry/kg wet})\end{array}\right)}\times\left(\begin{array}{c}\text{application}\\\text{rate (kg/ha)}\end{array}\right)\times\left(\begin{array}{c}\text{fraction}\\\text{that drifts}\end{array}\right)\times\left(\begin{array}{c}\text{residue rate}\\(\text{mg/kg food})/\\(\text{kg/ha})\end{array}\right)\times\left(\begin{array}{c}\text{fraction of}\\\text{diet that is}\\\text{contaminated}\end{array}\right)}{\text{organism body weight (kg)}} \quad \text{(S12)}$$

Equation S13 describes 90-day chronic exposure estimates for consumption of contaminated vegetation by herbivores. Scenarios were evaluated for wildlife eating vegetation on-site and off-site. In the on-site scenarios, the default Central, Lower, and Upper estimates assume that the herbivore spends 30 percent, 10 percent, or 100 percent of its time on-site. Table 2-20 summarizes the proportion of diet on-site parameters for the contaminated fruit and vegetation scenarios. Although these variables can be modified in the SERA worksheets, they were kept at these default settings for the Mount Sutro exposure estimates. Exposure estimates are directly proportional to the fraction of the diet that is eaten on-site. Exposures for off-site vegetation consumption assume that herbivores consume all of their food from vegetation that is either 25, 50, or 100 feet away from the application site (see Table 2-21). Drift estimates as a function of distance can be found in Table 2-20.[101] Note that the main difference between the acute scenario (S12) and the chronic scenario (S13) is the estimate of a residue decay rate (final term in the numerator in S13).

$$\text{Dose (mg/kg)} = \frac{\dfrac{\left(\begin{array}{c}\text{food needs}\\(\text{kcal})\end{array}\right)}{\left(\begin{array}{c}\text{kcal in dry}\\\text{food}\\(\text{kcal/kg food})\end{array}\right)\times\left(\begin{array}{c}\text{fraction}\\\text{dry}\end{array}\right)}\times\left(\begin{array}{c}\text{application}\\\text{rate (kg/ha)}\end{array}\right)\times\left(\begin{array}{c}\text{residue rate}\\(\text{mg/kg food})/\\(\text{kg/ha})\end{array}\right)\times\left(\begin{array}{c}\text{fraction of}\\\text{diet that is}\\\text{contaminated}\end{array}\right)\times\left(\dfrac{1-e^{\frac{-\ln(2)t}{\text{half-life}}}}{(\text{half-life})\times t}\right)}{\text{organism body weight (kg)}} \quad \text{(S13)}$$

**Table 2-20: Scenarios for Mammals and Birds Eating Contaminated Fruit or Vegetation**

| | | Lower, Central, Upper Estimates of | |
|---|---|---|---|
| **Scenario** | **Location** | **Proportion of Diet (%)** | **Proportion of application rate (%)** |
| Acute | On-site | 10%, 30%, 100% | 100% |
| Chronic | On-site | 10%, 30%, 100% | 100% |
| Chronic | Off-site | 100% | 0.5%, 1%, 2% |

*Data source:* Reference 12.

Equation S14 can also be used to calculate acute oral exposure for insectivorous mammals and birds. In the insectivore calculation, is it assumed that 100% of the diet comes from insects that were directly sprayed to estimate worst-case exposures. There is no equivalent calculation for chronic exposure because of the short lifetime of insects.

**Table 2-21: Fraction of Applied Herbicide Drifted as a Function of Distance**

| Distance from Application (ft) | Fraction Drifted |
|---|---|
| 25 | 0.00832 |
| 50 | 0.00433 |
| 100 | 0.00241 |
| 300 | 0.000941 |
| 500 | 0.000579 |
| 900 | 0.000312 |

*Data source:* USFS/SERA worksheet G05 from reference 12.

Determining the chemical dose from eating contaminated food requires an estimate of the amount of food ingested by the animal, obtained from the allometric equations in Table 2-16. The same scenario and equations may be applied to different taxa groups (for example, equations S14 and S15 are used for both large herbivorous mammals and birds); however, different allometric equations are used for the different taxa to determine the food intake parameter.

Doses for different wildlife groups vary because of different residue levels on food sources and different caloric densities. For example, animals that eat grasses and broadleaf vegetation will consume higher amounts of chemical residues than those that eat fruit because they need to eat a greater quantity of food to get the same caloric benefit. Table 2-22 shows the estimated range of chemical residues on vegetation for different vegetation types, as well as the caloric content of that vegetation. There are no experimental data that provide a quantitative measure of on-site chemical residues on insects. Chemical residues on small insects are assumed to be the same as for broadleaf vegetation (45 to 135 mg of herbicide per kg of vegetation).

**Table 2-22: Herbicide Residues and Caloric Density of Food**

| Contaminated media | Estimated Value |
|---|---|
| Broadleaf plants, small insects | 45–135 mg chem/kg |
| Fruits, seeds, large insects | 3.2, 7, 15 mg chem/kg |
| Short grass | 85–240 mg chem/kg |
| Caloric content in dry (wet) vegetation | 2.26 kcal/g (1.5 kcal/g) |
| Water fraction in vegetation | 85% |
| Caloric content in (wet) insects | 1.5 kcal/g |
| Caloric content in (wet) small mammals | 1.7 kcal/g |

*Data source:* USFS/SERA worksheet A02 from reference 12.

#### *2.5.4.D Exposures from Consumption of Contaminated Water*

Water contamination scenarios are described in Section 2.5.2 above. These calculations provide the concentrations used in the exposure estimates for terrestrial wildlife consuming contaminated water. The amount of water consumed by an animal was estimated using the allometric relationship between organism size and water consumed (Table 2-17). The USFS worksheets allow calculation of water consumption exposures for small and large mammals, carnivores and small and large birds.

### 2.5.5 Aquatic Wildlife Exposure Scenarios

Water contamination scenarios are described in Section 2.5.2. The calculated concentrations are used to assess the risks to aquatic organisms by comparing TRVs for aquatic organisms to calculated concentrations in Woodland Creek, the San Francisco Bay/Pacific Ocean and in puddles or pools on the Mount Sutro Reserve. Potential amphibian habitat is limited on much of Mount Sutro. Woodland Canyon is one such area because of the seasonal Woodland Creek. Once soil is saturated, Woodland Creek flows above and below Medical Center Way during rains and for days after.[102] Shallow pools that could serve as amphibian habitat have been observed in the lower part of Woodland Canyon, off Reserve land.[102] Steep slopes make standing pools of water or puddles after heavy rains unlikely within much of the Reserve, and many of the flatter areas (such as Rotary Meadow near the peak of Mount Sutro) tend to have good drainage due to rocky soils.[102] However, small puddles have been observed on trails, even in the summer from fog deposition (see Figure 2-8), and will likely exist for sufficient periods of time in the winter and spring to serve as drinking water supplies for small mammals and birds and possibly as breeding habitat for amphibians. Puddles that are more substantial are likely to be caused by ruts created by heavy equipment to be used for cutting and mulching, as discussed in Section 2.1.1.A.

**Demonstration Projects and Aquatic Wildlife Exposure Scenarios:** Runoff from Demonstration Project 1 (South Ridge Area) would not be intercepted by any permanent or seasonal body of water, with the exception of puddles that may form in ruts and indentations after rains. Demonstration Project 1 is predominantly sloped, however, so puddles are less likely. Demonstration Project 4 (East Bowl Corridor) begins upslope from the seasonal Woodland Creek and continues below Medical Center Way, where the Woodland Creek watercourse is. Based on the watershed delineation by Clearwater Hydrology (Figure 2-4) and site visits, a portion of the runoff from Demonstration Project 4 above Medical Center Way would be intercepted by the road, carried north, and captured by stormwater systems. However, part of the runoff from above Medical Center Way passes under the road via a culvert, and ultimately mingles with Woodland Creek. Thus Demonstration Project 4, in particular, poses a risk of exposure to mammals and birds drinking out of the creek and amphibians living in or near the creek. The exposure risk is lower than for the entire Reserve because fewer acres would be treated, but should a spill occur, aquatic species would be exposed to doses equivalent to those calculated for the Reserve as a whole, which would be determined by the volume and concentration of herbicide spilled.

### 2.5.6 Risk Characterization

Risk characterization is the final step in the risk assessment process in which likely exposures are compared to toxicity reference values (TRVs for wildlife and RfDs for humans). Hazard quotients (HQs) are the ratio of the exposure estimates to the TRVs. Selecting appropriate TRVs is a critical part of the risk assessment process; if they are not truly representative of doses at which adverse effects can occur, the risk assessment will not adequately represent the actual risks of using the chemical.

If the hazard quotient is greater than one, humans and wildlife may be expected to encounter toxic levels of a chemical in the environment. Human hazard quotients above one suggest that some individuals may experience adverse effects due to chemical exposure. Wildlife hazard quotients above one suggest that a population may experience adverse effects. The different

**Figure 2-8:** Even in the dry season, water from fog deposition collects in small puddles in the trails on Mount Sutro, as shown in these photographs taken on September 21, 2011, prior to the first rainfall of the season.

interpretations are a result of the extra protection afforded humans via intra- and inter-species uncertainty factors (see Section 2.2.1). Hazard quotients between 0.1 and 1.0 suggest that there may be particularly sensitive individuals or species that may be affected. Very low hazard quotients indicate low levels of risk for the effects that have been studied and are represented by the TRVs.

For wildlife, TRVs are generally based on NOAELs, with no uncertainty factors. Data were scarce for several of the herbicides evaluated, and often there were no studies with an NOEC or NOAEL endpoint, only studies with an $LC_{50}$ or $LD_{50}$ endpoint. The use of $LD_{50}$ or $LC_{50}$ values as toxicity reference values (TRVs) poses a concern, since killing 50% of a species may be problematic for the survival of that species or others that depend on it for food. In localized situations, killing 50% of the local population of an organism may not present a threat to the species, as long as the population is robust and there are pathways for rapid re-population of the treated area. However, if a large enough area is treated, and the exceedances of $LC_{50}$ or $LD_{50}$ values over areas of land or water are large enough to significantly inhibit repopulation of the area, or if the population is small, then using an $LD_{50}$ or $LC_{50}$ for a TRV is a poor choice for species protection.

In EPA's recent risk assessments for endangered or threatened species, when NOELs are not available, $LC_{50}$ or $LD_{50}$ values are adjusted to be surrogate NOELs.[103] Typically, the EPA reduces

the acceptable hazard quotients (the Estimated Environmental Concentration divided by the TRV) by a factor of 10 (for mammals and birds) or 20 (terrestrial invertebrates and aquatic animals) to reduce the risk of killing sensitive species (see Section 2.3.3). Table 2-23 summarizes EPA's approach. We use a similar approach, but adjust the $LC_{50}$-based TRVs *before* division by estimated environmental concentrations, so that the hazard quotient scale remains the same in all situations. Thus, in this risk assessment, hazard quotients less than one *always* mean that the anticipated environmental concentration did not exceed an RfD (for humans) or a NOAEL or NOEC (for wildlife).

**Table 2-23: US EPA's Interpretation of Hazard Quotients for Threatened and Endangered Species**

| Toxicity Endpoint | Hazard Quotient of Concern |
|---|---|
| Avian acute (based on $LD_{50}$ or $LC_{50}$) | > 0.1 |
| Avian chronic (based on NOAEC) | > 1 |
| Mammal acute (based on $LD_{50}$ or $LC_{50}$) | > 0.1 |
| Mammal chronic (based on NOAEC) | > 1 |
| Terrestrial invertebrates acute/chronic (based on $LD_{50}$) | > 0.05 |
| Terrestrial invertebrates acute/chronic (based on NOAEL) | >1 |
| Aquatic animals acute (based on $LC_{50}$) | > 0.05 |
| Aquatic animals acute (based on NOAEC) | > 1 |
| Terrestrial and semi-aquatic plants (based on $EC_{25}$) | > 1 |
| Aquatic plants (based on $EC_{50}$) | >1 |

*Data source:* Reference 103.

The chapter on each chemical contains a risk characterization section in which both human and wildlife hazard quotients are presented, with discussions of how the TRVs were selected for each chemical.

### 2.5.7 Uncertainties Associated with Risk Assessments

A well-done risk assessment provides information on the inherent hazards of a chemical, possible routes of exposure for humans and wildlife, and an estimated magnitude of exposure from which the likelihood of adverse effects and consequent risk may be estimated. This knowledge can in turn inform decision-making about when, where or whether to use herbicides in a particular situation. Risk assessments are also useful in highlighting knowledge gaps that can be filled via studies, trials, or monitoring programs.

A risk assessment does not provide a precise measure of risk, and even the most thorough risk assessments contain unverified assumptions and data gaps. Transparency of the methods used is important for validation of the assumptions made for a particular site. The developers of the USFS risk assessment model used for the Mount Sutro project, note that:[104]

> *In some respects, the transparency of a risk assessment is more important than the specific methods or calculations used to prepare it. Risk assessment is a form of analysis that relies on scientific method but is not itself a science. Reasonable individuals may disagree over which of the numerous methods, tools, and*

> *approaches should be used to prepare a risk assessment. Often, available information is not sufficient to support one analytical approach over another. Professional judgment must then be used to select the method; in which case, the risk assessment must clearly state which assumptions are used and why. As long as the assumptions are made clear, the quality of the risk assessment may be reviewed and the risk assessment may be critiqued as appropriate and improved in review.*

A number of assumptions and parameters are used to calculate estimated exposures. In order to estimate the range of results, it is useful to determine the model sensitivity to parameter variability. The USFS calculations provide an estimate of model sensitivity by calculating Upper, Lower and Central estimates to bracket a range of plausible exposures. Further, most of the parameters in human exposure models have been validated experimentally. Pesticide Research Institute (PRI) performed additional sensitivity tests for most of the remaining variables and published this work as part of the Herbicide Risk Assessment for the Marin Municipal Water District's Vegetation Management Plan.[105] The additional sensitivity tests did not reveal any parameters that had a disproportionally large impact on exposure model output.

Below we describe some of the uncertainties of the risk assessment process in detail.

#### *2.5.7.A Toxicity Assessment Uncertainties*

There are a number of unknowns in the toxicity assessments that increase the uncertainty of a risk assessment. It is difficult to know precisely how large an effect these uncertainties have on the ability to predict risks associated with herbicide use.

1. Most human RfDs are extrapolated from rats, mice, dogs or rabbits to humans, and adverse effects observed in animal studies may be different than what humans actually experience. To discover interspecies differences, US EPA will often require studies on two species of laboratory animal for some types of toxicity testing. In addition, US EPA builds in an interspecies uncertainty factor of 10 to account for this variation. This factor of 10 is not actually based on data, but is a convenient estimate. There are examples where interspecies differences in chemical sensitivity are both greater than and less than 10.[106] For wildlife, the problem is more significant, since TRVs for different taxa are often based on results from toxicity tests on just one or two surrogate species in a single taxa. An example of this is using the $LC_{50}$ for aquatic invertebrates as the TRV for fish. The USFS handles this issue for aquatic and terrestrial wildlife by developing separate risk estimates for "sensitive" and "tolerant" species when there is substantial variability in the data.
2. Different individuals have different susceptibilities to toxic substances. For humans, US EPA selects a toxicity endpoint from an animal study, and builds in an intraspecies uncertainty factor of 10 to account for the potential differences between different humans; however, the range of human susceptibility varies for every chemical and is not known for most chemicals. There are examples where intraspecies differences in chemical sensitivity are both greater than and less than 10.[106] There is no similar approach for wildlife; however, this may not be a serious limitation for animal TRVs since the range of individual variability can be explored in laboratory tests.

3. The use of a No Observed Adverse Effect Level (NOAEL) instead of a No Observed Effect Level (NOEL) allows for some effects that are clearly adverse to be classified as not adverse by regulators with discretion to render a value judgment. For example, US EPA recently characterized the development of ovaries and eggs in male frogs exposed to the herbicide atrazine as an effect, but would not go so far as to call it an adverse effect.[107] These classifications of endpoints almost certainly result in EPA-allowable exposures that may not be entirely without harm, even when both the inter- and intra-species uncertainty factors are used.

4. Developing organisms are particularly susceptible to the effects of toxic substances. An exposure that would normally not cause observable adverse effects in an adult animal can cause birth defects or interfere with normal fetal or childhood development. For humans, US EPA is required to use a child uncertainty factor to account for the vulnerability of children if there are data gaps or if studies show that the fetus or juvenile animals are more susceptible to the toxic effects of the chemical. However, because we often lack full knowledge of the mechanism of toxicity, this factor may not be sufficiently protective for effects that may not be readily observed in animal studies. No uncertainty factors are used for terrestrial and aquatic wildlife. However, for some chemicals, testing of juvenile animals, eggs, larvae and other developing organisms has been done and can be used to determine an endpoint appropriate to juveniles.

5. In laboratory studies, test species are exposed to only a single chemical. In the environment, humans and wildlife may be exposed to multiple toxicants simultaneously, which can lead to additive or synergistic effects.

6. In laboratory studies, test species are exposed to a constant dose of a chemical. In the environment, the more typical exposure pattern is a high pulse of pesticide concentration followed by a decline in exposure over time. Exposure measurements are often averaged over many hours or days, which may misrepresent the actual exposure experienced by humans and wildlife.

7. Not all types of toxicity are studied in detail. When there is insufficient information about disease-causing exposures, the risk assessment cannot fully evaluate these effects. Endocrine disruptors are an excellent example. These chemicals are potentially problematic at very low doses–doses typically not included in toxicity studies. While US EPA is now beginning to implement a screening program for endocrine disruptors, the agency has not tested currently registered pesticides for endocrine disruption. The USFS risk assessments for glyphosate and triclopyr and this report provide summaries of available literature studies on endocrine-disrupting effects.

#### *2.5.7.B Exposure Assessment Uncertainties*

In general, the USFS/SERA worksheets do a good job of providing realistic Lower, Central and Upper exposure estimates with a tendency to over-estimate exposures. There are a few exceptions, discussed in detail above and summarized below. In most of these situations, we have modified the exposure assessment to include additional scenarios that were omitted, or modified parameters to include all reasonably foreseeable scenarios.

1. Estimates of food intake per pound of body weight for wildlife are uncertain, but it is not clear how much this uncertainty will affect exposure estimates. More data are needed to determine if this issue is significant.
2. The runoff scenarios developed by USFS are derived from GLEAMS modeling, where contamination rates are expressed in mg/L per lb/acre. This water contamination rate does not consider the number of acres treated, the application rate, the size of the water body, the intensity of the rain event, the distance between the water body and the application site, the topographical specifics of the site and the time between application and runoff. In the interest of making a long-term runoff scenario that is more realistic in a Mediterranean climate, chemical degradation was assumed to occur for 0-120 days before fall rainfall and a maximum runoff scenario was developed.

An additional limitation of this type of risk assessment is that each member of the ecosystem is considered in isolation from other organisms, and trophic interactions (food webs) are not evaluated. Yet depletion of populations of organisms that serve as food source for others can be as devastating as a toxic dose of a chemical, particularly for organisms with a limited range, such as aquatic invertebrates, juvenile fish, or tadpoles. The exposure estimates for carnivores consider poisoning at multiple trophic levels, but not the effects due to the reduction in predator food supplies from depletion of prey populations.

# References For Chapter 2

[1] UCSF Campus Planning. 2010. Notice of Preparation / Initial Study: University of California San Francisco Mount Sutro Management. http://campusplanning.ucsf.edu/pdf/Initial_Study_UCSF_Mt_Sutro_Mgmt.pdf.

[2] USFS Pesticide Surveys can be found at: http://www.fs.fed.us/foresthealth/pesticide/risk.shtml.

[3] US EPA. 2011. *Pesticide Reregistration Status*. http://www.epa.gov/oppsrrd1/reregistration/status.htm.

[4] US EPA. 2011. *Reevaluation: Review of Registered Pesticides.* http://www.epa.gov/oppsrrd1/reevaluation.

[5] a) US EPA. 2011. *Endangered Species Effects Determinations and Consultations*. Available: http://www.epa.gov/espp/litstatus/effects/.
b) US EPA. 2011. Effects Determinations for the California Red-legged Frog and other California Listed Species | Endangered Species Protection Program: Pesticides. http://www.epa.gov/espp/litstatus/effects/redleg-frog.

[6] US EPA. *Ecotox database*. US Environmental Protection Agency. http://www.epa.gov/ecotox.

[7] US NTP. 2006. *NTP Study Reports: Long-Term Study Reports and Abstracts.* US National Toxicology Program. http://ntp-server.niehs.nih.gov/index.cfm?objectid=084801F0-F43F-7B74-0BE549908B5E5C1C

[8] WHO. *Environmental Health Criteria 159: Glyphosate*. World Health Organization International Programme on Chemical Safety. http://www.inchem.org/documents/ehc/ehc/ehc159.htm.

[9] John Brown and Sons. 2011. Brown Brontosaurus EVO Mulchers and Mowers - Advanced Land Clearing Technology. http://www.brownbronto.com.

[10] Klatt, T. 2004. UC Berkeley Fire Fuel Management Brontosaurus Project: Frowning Ridge-Chaparral Hill Project Report. http://oep.berkeley.edu/pdf/FireProjects/CH1_rpt_USFW.pdf.

[11] Howard, S and Parker, R. 1995. Chemical Control for Woody Plants, Stumps and Trees. Washington State University Cooperative Extension. http://cru.cahe.wsu.edu/CEPublications/eb1551/eb1551.html.

[12] USFS. 2011. Glyphosate Human Health and Ecological Risk Assessment: Final Report. http://www.fs.fed.us/foresthealth/pesticide/pdfs/Glyphosate_SERA_TR-052-22-03b.pdf.

[13] Ferrel, J, Langeland, K, Sellers, B. 2006. Herbicide Application Techniques for Woody Plant Control. Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu/ag245.

[14] Dow AgroSciences. 2011. Forestry Vegetation Management: Cut-stump. https://www.dowagro.com/ivm/forestry/prod/stump.htm.

[15] Monsanto. 2011. Stump Control Using Roundup Pro Biactive. http://www.monsanto-ag.co.uk/content.output/237/237/Roundup/Application%20Information/Stump%20Treatment.mspx.

[16] USFS. 2010. Environmental Assessment: Terrestrial Invasive Plant Species (TIPS) Treatment Project. Lake Tahoe Basin Management Unit, US Forest Service. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5209401.pdf.

[17] Miller JH, USDA Forest Service, Bugwood.org. http://www.ipmimages.org/browse/detail.cfm?imgnum=2307263.

[18] University of Arizona, College of Agriculture and Life Sciences. 2006. Cut-stump Application of Herbicides to Manage Woody Vegetation. http://ag.arizona.edu/pubs/garden/az1401.pdf.

[19] Holmes KA, Berry AM. 2009. Evaluation of off-target effects due to basal bark treatment for control of invasive fig trees (Ficus carica). *Invasive Plant Science and Management* 2:345–351.

[20] Nowak CA, Ballard BD. 2005. Off-Target Herbicide Deposition Associated with Treating Individual Trees. Environmental Management 36:237-247; doi:10.1007/s00267-004-0080-3.

[21] Dow AgroSciences. 2008. Specimen Label: Garlon® 4 Ultra Specialty Herbicide, EPA Reg No. 62719-527. http://www.cdms.net/manuf/1prod.asp?pd=8141&lc=0.

[22] USFS. 2011. *Triclopyr Human Health and Ecological Risk Assessment Final Report.* 2011. Prepared for the US Forest Service by Syracuse Environmental Research Associates. http://www.fs.fed.us/foresthealth/pesticide/pdfs/052-25-03aTriclopyr.pdf.

[23] Bossard, CC, Randall, JM, and Hoshovsky, MC, eds. 2000. Invasive Plants of California's Wildland, entry for *Eucalyptus globulus*. California Invasive Plant Council. http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=48&surveynumber=182.php.

[24] Siso, CL and Burzycki, GM 2004. Survival of shoebutton ardisia (*Ardisia elliptica*) in forested wetlands after cut-stump treatment with triclopyr. *Weed Technology*, Invasive Weed Symposium, *18*: 1422-1426.

[25] Santos, GL, Cuddihy, LW, and Stone, CP 1991. Control of yellow Himalayan raspberry (*Rubus ellipticus sm.*) with cut-stump herbicide treatments in Hawaii Volcanoes National Park (Technical Report No. 80). http://scholarspace.manoa.hawaii.edu/handle/10125/7167.

[26] Gresham CA. 2010. Efficacy of 'hack and squirt' application of imazapyr, triclopyr, and glyphosate to control the invasive tree species Chinese tallowtree. In Stanturf, John A, ed. 2010. *Proceedings of the 14th Biennial Southern Silvicultural Research Conference.* Gen. Tech. Rep. SRS–121. US Department of Agriculture, Forest Service, Southern Research Station. 614 p. http://www.srs.fs.fed.us/pubs/gtr/gtr_srs121/gtr_srs121.pdf.

[27] Kochenderfer, JD, Kochenderfer, JN, and Miller, GW 2006. Controlling beech root and stump sprouts using the cut-stump treatment. *Northern Journal of Applied Forestry*, *23*, 155-165.

[28] USFS, Francis JK. Schinus terebinthifolius - Brazilian pepper tree. http://www.fs.fed.us/global/iitf/pdf/shrubs/Schinus%20terebinthifolius.pdf

[29] *Panetta*, FD and Anderson, TM D. 2001. Chemical control of broad-leaved pepper tree (*Schinus terebinthifolius Raddi*). *Plant Protection Quarterly*. 16: 26-31.

[30] LaSala, AV, and Dingle, JK 2000. The effect of seasonal and climatic factors on *Eucalyptus obliqua* mortality in response to stem injection of glyphosate. *Tasforests-Hobart*, 12:11–20.

[31] Altland, J, Ream, J. 2010. Control of Butterfly Bush with Postemergence Herbicides. 5. http://ddr.nal.usda.gov/bitstream/10113/44385/1/IND44404760.pdf.

[32] Mallik AU, Wood K, Hollstedt C, McLaughlan. 1997. Cut-stump herbicide treatments to reduce sprouting and root suckering. TN-39, in Bell, FW, McLaughlan, MS and Kerley, J (compilers). *Vegetation Management Alternatives - A Guide to Opportunities.* Ontario Ministry of Natural Resources, Thunder Bay, ON.

[33] a) US EPA, 2009. Endocrine Disruptor Screening Program; Policies and Procedures for Initial Screening. *Fed Regis* 74(71): 17560-17579. Wednesday, April 15, 2009.

b) US EPA, 2009. Final List of Initial Pesticide Active Ingredients and Pesticide Inert Ingredients to be Screened Under the Federal Food, Drug, and Cosmetic Act. *Fed Regis* 74(71): 17579-17585. Wednesday, April 15, 2009.

[34] Bearer CF. 1995. How are children different from adults? *Environ Health Perspect* 103(Suppl 6): 7–12.

[35] Bruckner JV, Weil WB. 1999. Biological factors which may influence an older child's or adolescent's responses to toxic chemicals. *Regul Toxicol Pharmacol* 29(2 Pt 1): 158–164.

[36] *American Association of Poison Control Centers.* http://www.aapcc.org/DNN/.

[37] Baker EL. 1989. Sentinel event notification system for occupational risks (SENSOR): IV. The concept. *Am J Pub Health* 79(Suppl): 18–20.

[38] Schnitzer PG, Shannon J. 1999. Development of a surveillance program for occupational pesticide poisoning: lessons learned and future directions. *Publ Health Rep* 114(3): 242–248.

[39] NIOSH. *Pesticide Illness and Injury Surveillance.* National Institute for Occupational Safety and Health. http://www.cdc.gov/niosh/topics/pesticides/overview.html.

[40] CA DPR. *Pesticide Illness Surveillance Program.* California Department of Pesticide Regulation. http://www.cdpr.ca.gov/docs/whs/pisp.htm.

[41] OSHA. *A–Z Index of Workplace Hazards.* Occupational Safety and Health Administration, US Department of Labor. http://www.osha.gov/html/a-z-index.html.

[42]ACGIH. *ACGIH Home Page.* American Conference of Government Industrial Hygenists. http://www.acgih.org.

[43] US EPA. 2005. *Guidelines for Carcinogen Risk Assessment.* US Environmental Protection Agency, March 2005. EPA/630/P-03/001B. http://www.epa.gov/IRIS/cancer032505.pdf.

[44] Jones RE, Lopez KH. 2006. *Human Reproductive Biology.* 3rd Edition. Academic Press (New York).

[45] Edmonds DK, Lindsay KS, Miller JF, *et al.* 1982. Early embryonic mortality in women. *Fertil Steril* 38(4): 447–453.

[46] Miller JF, Williamson E, Glue J, *et al.* 1980. Fetal loss after implantation. A prospective study. *Lancet.* 2(8194): 554–546.

[47] NIH-Medline. *Medical Encyclopedia.* National Institutes of Health, Medline Plus. http://www.nlm.nih.gov/medlineplus/ency/article/001488.htm.

[48] NIH-NCI. *Agricultural Health Study,* National Institutes of Health, National Cancer Institute. http://aghealth.nci.nih.gov.

[49] Alavanja MCR, Sandler DP, McMaster SB, *et al.* 1996. The Agricultural Health Study**.** Environ Health Perspect 104: 362–369.

[50] US EPA. 2011. Welcome to ECOTOX. Environmental Protection Agency. http://cfpub.epa.gov/ecotox/.

[51] US EPA. *Series 850 Ecological Test Guidelines.* US EPA Office of Pollution Prevention and Toxic Substances Harmonized Test Guidelines. US EPA. http://www.epa.gov/opptsfrs/publications/OPPTS_Harmonized/850_Ecological_Effects_Test_Guidelines/Drafts/.

[52] Davidson C, Knapp RA. 2007. Multiple stressors and amphibian declines: dual impacts of pesticides and fish on yellow-legged frogs. *Ecol Appl,* 17(2): 587–597, and references cited therein.

[53] This assertion for glyphosate comes from evaluation of the glyphosate toxicity literature of different species and an analysis of the EPA Ecotox data (http://www.epa.gov/ecotox).

[54] CA DPR. *Toxic Air Contaminant Program Monitoring Reports.* California Department of Pesticide Regulation web site. http://www.cdpr.ca.gov/docs/emon/pubs/tac/tacstdys.htm

[55] US EPA 2008. Risks of Glyphosate Use to Federally Threatened California Red-legged Frog: Pesticide Effects Determination. Appendix A. US Environmental Protection Agency. http://www.epa.gov/espp/litstatus/effects/redleg-frog/#glyphosate.

[56] US EPA. *Series 870 Health Effects Test Guidelines*, US EPA Office of Pollution Prevention and Toxic Substances Harmonized Test Guidelines, US EPA, http://www.epa.gov/opptsfrs/publications/OPPTS_Harmonized/870_Health_Effects_Test_Guidelines/ Series/.

[57] Kamrin, MA. 1997. *Pesticide Profiles: Toxicity, Environmental Impact, and Fate*. Lewis Publishers. Boca Raton, FL.

[58] Linz GM, Bergman DL, Homan HJ, Bleier WJ. 1995. Effects of herbicide-induced habitat alterations on blackbird damage to sunflower. Crop Protection 14:625-629; doi:10.1016/0261-2194(95)00072-0. http://www.sciencedirect.com/science/article/pii/0261219495000720

[59] Santillo 1994 in USFS 2011, reference 12.

[60] (a) See Anthony and Morrison 1985 in USFS 2011, reference 12.

(b) D'Anieri *et al.* 1987 in USFS 2011, reference 12.

(c) Ritchie *et al.* 1987 in USFS 2011, reference 12.

(d) Santillo *et al.* 1989a in USFS 2011, reference 12.

(e) Sullivan 1990 in USFS 2011, reference 12.

(f) Sullivan *et al.* 1997 in USFS 2011, reference 12.

(g) Sullivan *et al.* 1998a in USFS 2011, reference 12.

(h) Vreeland *et al.* 1998 in USFS 2011, reference 12.

(j) Hjeljord *et al.* 1988 in USFS 2011, reference 12.

[61] (a) Cayford 1988 in USFS 2011, reference 12.

(b) Easton and Martin 1998 in USFS 2011, reference 12.

(c) Freemark and Boutin 1995 in USFS 2011, reference 12.

(d) Linz *et al.* 1994 in USFS 2011, reference 12.

(e) Linz 1996 in USFS 2011, reference 12.

(f) Linz and Blixt 1997 in USFS 2011, reference 12.

(g) MacKinnon and Freedman 1993 in USFS 2011, reference 12.

(h) Solberg and Higgins 1993 in USFS 2011, reference 12.

[62] (a) Brust, GE. 1990 from USFS 2011, reference 12.

(b) Duchesne LC, Lautenschlager RA and Bell FW. 1999 in USFS 2011, reference 12.

[63] (a) Byers and Bierlein 1984 in USFS 2011, reference 12.

(b) Freemark and Boutin 1995 in USFS 2011, reference 12.

(c) Yokoyama and Pritchard 1984 in USFS 2011, reference 12.

[64] Kisseberth *et al.* 1986 in USFS 2011, reference 12.

[65] Colborn T, Carroll LE, 2007. Pesticides, Sexual Development, Reproduction and Fertility: Current Perspectives and Future Directions. *Human and Ecological Risk Assessment* 13:1078–1110.

[66] SF Medical Society. 2008. Myers JP, vom Saal FS. Time to Update Environmental Regulations: Should public health standards for endocrine-disrupting compounds be based upon sixteenth century dogma or modern endocrinology? and references cited therein. *San Francisco Medicine Magazine*, San Francisco Medical Society. Jan/Feb 2008. http://www.sfms.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/HTMLDisplay.cfm &CONTENTID=2506.

[67] EC DG ENV 2000. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption.* European Commission DG ENV. Prepared by BKH Consulting Engineers in association TNO Nutrition and Food Research. http://ec.europa.eu/environment/docum/01262_en.htm.

[68]US EPA. 1996. *Food Quality Protection Act of 1996.* US Environmental Protection Agency. http://www.epa.gov/pesticides/regulating/laws/fqpa/.

[69] US EPA. *Endocrine Disruptor Screening Program.* US Environmental Protection Agency, http://www.epa.gov/scipoly/oscpendo/index.htm.

[70] US EPA. 2007. *Assay Development and Validation.* US Environmental Protection Agency. http://www.epa.gov/scipoly/oscpendo/pubs/assayvalidation/index.htm.

[71] US EPA. 2007. *Overview of the June 2007 Draft List of Chemicals for Initial Tier 1 Screening.* US Environmental Protection Agency, http://www.epa.gov/scipoly/oscpendo/pubs/prioritysetting/listfacts.htm.

[72] US EPA. 2007. *Draft Policies and Procedures for the Endocrine Disruptor Screening Program.* US Environmental Protection Agency, http://www.epa.gov/scipoly/oscpendo/pubs/regaspects/index.htm.

[73] US EPA. 2010. *Second List of Chemicals for Tier I Screening.* US Environmental Protection Agency. http://www.epa.gov/endo/pubs/prioritysetting/draftlist2.htm.

[74] US NTP. 2011. *Endocrine Disruptor: Overview of Projects*, US National Toxicology Program. November 7, 2011. http://iccvam.niehs.nih.gov/methods/endocrine/endocrine.htm.

[75] US NTP 2003. *Endocrine Disruptor: Test Method Evaluation Report*. US National Toxicology Program. April 15, 2008. http://iccvam.niehs.nih.gov/methods/endocrine/end_TMER.htm.

[76] CDPR. 2009. *2008 Status Report: Pesticide Contamination Prevention Act*, Report # EH 09-02. January 2009. California Department of Pesticide Regulation. http://www.cdpr.ca.gov/docs/legbills/reports/reg/data_gap/datagap.htm.

[77] (a) Weber JB, Wilkerson GG, Reinhardt CF. 2004. Calculating pesticide sorption coefficients ($K_d$) using selected soil properties. Chemosphere 55:157–166.

(b) Wauchope RD, Yeh, S, Linders JBHJ, *et al.* 2002. Pesticide soil sorption parameters; theory, measurement, uses, limitations and reliability. *Pest manag Sci* 48:419–445.

[78] Gregson J. 2011. San Francisco Public Utilities Commission. Personal communication.

[79] NOAA. 2004. *Climatography of the United States No. 20, 1971-2000: San Francisco Downtown, CA.* National Oceanic and Atmospheric Administration. http://cdo.ncdc.noaa.gov/climatenormals/clim20/ca/047772.pdf

[80] Hwang H-M, Young TM. 2011. *Final Report: Environmental decay of glyphosate in broom-infested Mt. Tamalpais soils and its transport through stormwater runoff and soil column infiltration.* Submitted to Marin Municipal Water District, April 19, 2011. Obtained from Janet Klein at MMWD.

[81] Personal communication with Bill Vandivere of Clearwater Hydrology, November 2011.

[82] Ramirez-Herrera, MT, Sowers, JM, and Richard, CM. 2006. Creek and Watershed Map of San Francisco. Oakland Museum of California, Oakland CA. 1:25,800 scale. htttp://www.museumca.org/creeks.

[83] UCSF. 2001. *Mount Sutro Open Space Reserve Management Plan, September 2001*. University of California, San Francisco. September 2001. campusplanning.ucsf.edu/pdf/Mount_Sutro_Reserve_Plan.pdf.

[84] Clearwater Hydrology. 2011. SCS Runoff, Peak Discharge and Synthetic Hydrograph Calculations. August 10, 2011.

[85] Gregson J, San Francisco Public Utilities Commission. 2011. San Francisco Wastewater Treatment Plant Wet Weather Capacities.

[86] (a) Ecobichon 1998 in USFS 2011, reference 12.

(b) van Hemmen 1992 in USFS 2011, reference 12.

[87] USFS. 2007. *Preparation of Environmental Documentation and Risk Assessments for the USDA/Forest Service*. http://www.sera-inc.com/fsmethods.html or http://www.fs.fed.us/foresthealth/pesticide/pdfs/PrepEnvirmentalDoc_01-07.pdf.

[88] Pesticide Research Institute calculation based on HortScience, Inc., Kelley and Associates Environmental Sciences, Royston, Hanamoto Alley and Abey, Martin Whitcomb Landscape. 1999. Mount Sutro Open Space Reserve Maintenance and Restoration Plan. http://www.ucsf.edu/sites/default/files/documents/HortScience.pdf

[89] (a) Edmiston *et al.* 1995 in USFS 2011, Reference 12.

(b) Jauhianen *et al.* 1991 in USFS 2011, Reference 12.

(c) Lavy *et al.* 1992 in USFS 2011, Reference 12.

(d) Machado-Neto *et al.* 2000 in USFS 2011, 12.

(e) Middendorf 1993 in USFS 2011, Reference 12.

(f) Schneider *et al.* 1999 in USFS 2011, Reference 12.

[90] Lavy TL, Norris LA, Mattice JD, *et al.* 1987. Exposure of forestry ground workers to 2,4-D, picloram and dichlorprop. *Envi Toxicol Chem* 6:209–224.

[91] (a) US EPA. 2011. *Exposure Factors Handbook*. Office of Research and Development, US Environmental Protection Agency. http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252.

(b) US EPA. 1992. *Dermal Exposure Assessment: Principles and Applications.* 1992. US Environmental Protection Agency, EPA/600/8-91/011B. http://www.epa.gov/opptintr/exposure/presentations/efast/usepa_1992d_dermalea.pdf.

[92] (a) US EPA. 1992. *Dermal Exposure Assessment: Principles and Applications.* US Environmental Protection Agency. EPA/600/8-91/011B. January 1992. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12188.

(b) US EPA. 2007. *Dermal Exposure Assessment: A Summary of EPA Approaches.* US Environmental Protection Agency. EPA/600/R-07/040F. September 2007. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=183584.

[93] The USFS/SERA worksheets are set up to modify all parameters simultaneously, with the Upper exposure estimate utilizing all parameters that would provide the highest dose estimate and the Lower exposure estimate utilizing all parameters that would provide the lowest dose estimate. For the direct spray and accidental worker exposure scenarios, we wished to compare only the effects of changing the concentration of the solution. Utilization of Upper and Lower $K_p$ values in this calculation resulted in nonsensical exposure estimates for the purposes of comparison of effects from changing only the concentration.

[94] Durkin *et al.* 1995 in USFS 2011, Reference 12.

[95] Wahlers RL, Burton JD, Maness EP, *et al.* 1997. Physiological characteristics of a stem cut and blade delivery method of application. *Weed Science* 45:746-749.

[96] True SL. *The Biology and Control of Beach Vitex (Vitex rotundifolia) and Common Reed (Phragmites australis)*. A thesis submitted to the Graduate Faculty of North Carolina State University In partial fulfillment of the requirements for the degree of Master of Science in Crop Science, Raleigh, North Carolina. repository.lib.ncsu.edu/ir/bitstream/1840.16/1164/1/etd.pdf.

[97] US EPA. 1993. *Wildlife Exposure Factors Handbook. Volumes 1 and 2.* 1993. US Environmental Protection Agency/Office of Research and Development). EPA/600/R-93/187a,b. Available NTIS: PB94-174778 and PB94-174779. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2799.

[98] A second relationship between the size of an organism in a taxa and its chemical sensitivity has been suggested. One study found that smaller birds are typically *more sensitive* than larger birds to pesticides. The study also stated that the reverse was true for mammals, see reference 52. These relationships have been used sporadically by the EPA to adjust endpoints for mammals and birds. However, the glyphosate Ecotox data did not show any remarkable

differences between different sized organisms. This relationship would not change an organism's expected exposure, but rather the organism's expected TRV.

[99] Boxenbaum and D'Souza 1990 in USFS 2011, Reference 12.

[100] Newton *et al.* 1984, in USFS 2011, Reference 12.

[101] Teske *et al.*2000. AgDRIFT. http://www.agdrift.com.

[102] Dawson, C. 2011. Personal communication with Craig Dawson, Executive Director, Sutro Stewards. August 25, 2011.

[103] US EPA. 2011. *Effects Determination for the California Red-legged Frog and Other California Listed Species.* See for example Appendix C for the glyphosate Effects Determination for a description of this process. http://www.epa.gov/espp/litstatus/effects/redleg-frog/#glyphosate

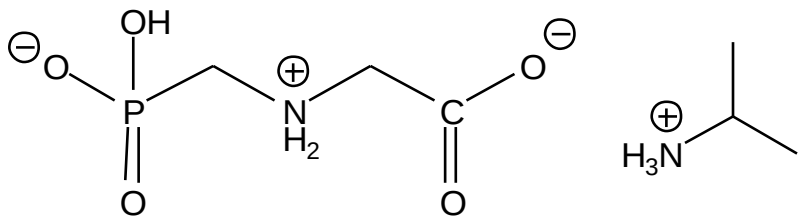
[104] SERA, Durkin PR. 2007. Preparation of Environmental Documentation and Risk Assessments for the USDA/Forest Service. http://www.sera-inc.com/fsmethods.html.

[105] Pesticide Research Institute. 2008. Marin Municipal Water District Vegetation Management Plan: Herbicide Risk Assessment. Prepared for Marin Municipal Water District. Section 2.5.4. http://www.marinwater.org/controller?action=menuclick&id=437.

[106] Vermeire T, Pieters M, Rennen M, *et al.* 2001. *Probabilistic Assessment Factors for Human Health Risk Assessment: A Practical Guide.* Danish National Institute of Public Health and the Environment, TNO Nutrition and Food Research. http://rivm.openrepository.com/rivm/handle/10029/9560.

[107] Hayes, T. 2008. Personal communication with Professor Tyrone Hayes, University of California, Berkeley. January 2008.

# Chapter 3 — Glyphosate



# 3 Table of Contents — Glyphosate

**3.1 INTRODUCTION ..... 3-5**

**3.2 GLYPHOSATE TOXICITY TO HUMANS AND LEVELS OF CONCERN ..... 3-6**

3.2.1 HEALTH EFFECTS ..... 3-7
3.2.1.A Acute Effects—Skin ..... 3-7
3.2.1.B Acute Effects—Eyes ..... 3-8
3.2.1.C Acute Effects—Asthma ..... 3-9
3.2.1.D Acute Effects—Systemic Poisoning ..... 3-9
3.2.1.E Chronic Health Effects—Cancer ..... 3-9
3.2.1.F Chronic Health Effects—Rhinitis ..... 3-13
3.2.1.G Reproductive Effects ..... 3-13
3.2.1.H Chronic Health Effects—Neurological ..... 3-16
3.2.1.I Levels of Concern for Humans ..... 3-16
3.2.2 ROUTES OF EXPOSURE ..... 3-16
3.2.3 BIOMONITORING STUDIES ..... 3-17
3.2.4 PESTICIDE ILLNESS REPORTS ..... 3-20

**3.3 GLYPHOSATE TOXICITY TO ANIMALS AND PLANTS AND LEVELS OF CONCERN ..... 3-22**

3.3.1 MAMMALS ..... 3-22
3.3.1.A Metabolism and Pharmacokinetics of Glyphosate ..... 3-23
3.3.1.B Acute Toxicity of Glyphosate ..... 3-24
3.3.1.C Reproductive and Developmental Toxicity of Glyphosate ..... 3-25
3.3.1.D Endocrine Disruption ..... 3-29
3.3.1.E Sub-Chronic Toxicity of Glyphosate ..... 3-36
3.3.1.F Chronic Toxicity and Carcinogenicity of Glyphosate ..... 3-36
3.3.1.G Genetic Toxicity and Oxidative Stress ..... 3-39
3.3.1.H Neurotoxicity ..... 3-41
3.3.1.I Immunotoxicity ..... 3-43
3.3.1.J Effects on Mammalian Wildlife ..... 3-43
3.3.1.K Levels of Concern for Mammals ..... 3-44
3.3.1.L Data Gaps ..... 3-44
3.3.2 OTHER TERRESTRIAL ORGANISMS ..... 3-45
3.3.2.A Birds ..... 3-45
3.3.2.B Terrestrial Invertebrates ..... 3-46
3.3.2.C Terrestrial Plants ..... 3-48
3.3.2.D Soil Microbes ..... 3-50
3.3.3 AQUATIC ORGANISMS ..... 3-51
3.3.3.A Fish ..... 3-52
3.3.3.B Amphibians ..... 3-53
3.3.3.C Aquatic Invertebrates ..... 3-57
3.3.3.D Aquatic Plants ..... 3-58
3.3.4 DATA GAPS ..... 3-59

**3.4 ENVIRONMENTAL FATE OF GLYPHOSATE ..... 3-63**

3.4.1 OVERVIEW ..... 3-63
3.4.2 WATER SOLUBILITY AND SOIL BINDING OF GLYPHOSATE ..... 3-63
3.4.3 PERSISTENCE OF GLYPHOSATE ..... 3-65
3.4.3.A Microbial Degradation ..... 3-68
3.4.3.B Transport by Air ..... 3-69
3.4.3.C Transport by Water ..... 3-70
3.4.3.D Uptake by Plants ..... 3-71

3.4.3.E Field Studies on the Environmental Fate of Glyphosate ..... 3-71
3.4.4 AQUAMASTER PRODUCT PROFILE ..... 3-73
3.4.5 KNOWN IMPURITIES ..... 3-74
**3.5 EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION FOR GLYPHOSATE ..... 3-74**
3.5.1 CHEMICAL-SPECIFIC EXPOSURE PARAMETERS FOR GLYPHOSATE ..... 3-76
3.5.2 APPLICATION METHODS FOR GLYPHOSATE ..... 3-77
3.5.3 WATER CONTAMINATION ESTIMATES ..... 3-77
3.5.4 RISKS TO HUMANS ..... 3-82
3.5.4.A Workers ..... 3-82
3.5.4.B General Public ..... 3-87
3.5.5 RISKS TO WILDLIFE ..... 3-93
3.5.5.A Terrestrial Wildlife ..... 3-93
3.5.5.B Terrestrial Plants ..... 3-106
3.5.5.C Aquatic Wildlife ..... 3-106
**REFERENCES FOR CHAPTER 3 ..... 3-117**

# Table of Tables

Table 3-1: Calls to US Poison Control Centers Related to Glyphosate Exposure 2002 to 2006 ..... 3-20
Table 3-2: Glyphosate-related Illnesses Reported by California Physicians To the Pesticide Incident Surveillance Program (PISP), 1997 to 2006 ..... 3-21
Table 3-3. Acute Toxicity of Glyphosate in Experimental Animals ..... 3-25
Table 3-4: Reproductive and Developmental Toxicity of Glyphosate to Mammals ..... 3-28
Table 3-5: Comparison of Glyphosate Concentrations Expressed as Percent of Formulated Product ..... 3-33
Table 3-6: Sub-chronic Toxicity of Glyphosate to Mammals ..... 3-37
Table 3-7: Chronic Toxicity of Glyphosate to Mammals—Cancer ..... 3-38
Table 3-8: Comparison of Glyphosate Toxicity Reference Values (TRVs) Used in USFS and Mount Sutro Risk Assessments ..... 3-61
Table 3-9: Chemical and Physical Properties of Glyphosate ..... 3-63
Table 3-10: Half-Life of Glyphosate Under Different Conditions ..... 3-66
Table 3-11: Glyphosate-Specific Exposure Parameters ..... 3-76
Table 3-12: Application Rate and Application Volume Model Inputs for Aquamaster ..... 3-77
Table 3-13: Calculated Glyphosate Concentrations for Water Contamination Scenarios ..... 3-79
Table 3-14: Percent of Glyphosate Lost as a Function of Annual Rainfall and Soil Type ..... 3-81
Table 3-15: Glyphosate Concentrations at Wastewater Treatment Plants During the 5-Year Storm ..... 3-82
Table 3-16: Estimated Risks for Workers from Glyphosate Exposures ..... 3-85
Table 3-17: Estimated Risks for the General Public from Glyphosate Accidental Acute Dermal Exposures ..... 3-89
Table 3-18: Estimated Risks for Humans Drinking Glyphosate-Contaminated Water ..... 3-91
Table 3-19: Estimated Risks for Terrestrial Wildlife Exposed to Glyphosate through Direct Sprays and Food Consumption ..... 3-97
Table 3-20: Estimated Risks for Mammals Drinking Glyphosate-Contaminated Water ..... 3-99
Table 3-21: Estimated Risks for Birds Drinking Glyphosate-Contaminated Water ..... 3-103
Table 3-22: Estimated Risks for Sensitive Amphibians and Fish Exposed to Glyphosate-Contaminated Water .. 3-109
Table 3-23: Estimated Risks for Sensitive Aquatic Invertebrates Exposed to Glyphosate-Contaminated Water .. 3-113
Table 3-24: Estimated Risks for Aquatic Plants Exposed to Glyphosate-Contaminated Water ..... 3-115

## 3.1 Introduction

Glyphosate is a post-emergent, non-selective phosphonoglycine herbicide widely used on crops, in forestry, and in residential settings. Glyphosate kills plants by restricting the shikimic acid pathway that allows plants to synthesize phenolic compounds and amino acids. Disruption of this pathway inhibits photosynthesis, cellular growth, and nucleic acid production.

Glyphosate was first registered as the isopropylamine salt in 1974. US EPA estimates that 180-185 million pounds of glyphosate were applied to US crops and forests in 2007, making it the most heavily used pesticide in the agricultural sector.[1] An additional estimated 18–23 million pounds were used in home gardens and for governmental uses in 2007. Since 2007, the sales and use of glyphosate-containing products has increased in both annual application rates and in fraction of use compared to other herbicides. In California, where more recent data are available, use of glyphosate and its salts in agriculture increased from 14.27 million pounds in 2007 to 17.23 million pounds in 2009, largely due to an increasing number of acres planted in glyphosate-tolerant, genetically modified crops.[2] Glyphosate is currently registered for use in the European Union and was re-evaluated by the EU most recently in 2001.[3]

Surfactants are often added to herbicide products to increase the absorption of the active ingredient and may contribute to their toxicity.[4] The presence of such "inert" ingredients is especially relevant for glyphosate products, in which one of the commonly used "inerts"—polyoxyethyleneamine (POEA)—has been found to be more toxic than glyphosate itself. Manufacturers are not required to provide the specific identity and concentrations of each "inert" ingredient in a pesticide formulation. Without such information, it is difficult to determine the potential contribution of the inert ingredient to the toxicity of the marketed product.

In an effort to distinguish the relative toxicities of various glyphosate formulations, the USFS compared 35 of the most common glyphosate products (see Appendix 3a in reference 5), many of which contain POEA. Polyoxyethyleneamine (POEA) surfactants are not under consideration for use in this project due to their known high toxicity to aquatic organisms; therefore, this risk assessment does not present a comprehensive discussion of all glyphosate products. Much of the toxicity data, especially the peer-reviewed literature, focuses on commercial formulations of glyphosate, with particular attention given to Roundup. Restricting this report only to products like Aquamaster (the glyphosate-based herbicide being considered for use on Mount Sutro, which contains only glyphosate and water), or even technical-grade glyphosate, would discard a wealth of data on glyphosate toxicity. We take an intermediate position in this risk assessment: *focusing* on studies that use glyphosate with no surfactant, but also including studies in which products with surfactants are used for perspective. Every attempt is made to be clear about what substance is being referred to in the text. "Technical grade" glyphosate refers to glyphosate without surfactants.

No surfactants are present in the Aquamaster product, but the label does recommend mixing the product with a surfactant prior to use. UCSF is considering Competitor, which contains ethyl oleate and alkyl ethoxylates, as a surfactant. The use of glyphosate with a surfactant may change the risks associated with glyphosate use, but Competitor is less acutely toxic to aquatic

organisms than POEA and does not contain any known endocrine disrupting compounds. See Chapter 5 for more information about the surfactant ingredients.

This chapter focuses on the human and mammalian toxicity, ecotoxicity, and environmental fate of glyphosate, drawing from the United States Forest Service's Human Health and Ecological Risk Assessment of 2011[5] (USFS 2011), US EPA's Re-registration Decision of 1993[6] (RED 1993) and 2006 update,[7] the 2008 California Red-legged Frog Effects Determination[8] and the EPA Ecotox database[9] (Terretox for the terrestrial database and AQUIRE for the aquatic database), the World Health Organization (WHO) glyphosate evaluation,[10] and the California Office of Environmental Health Hazard Assessment Public Health Goal evaluation for glyphosate in drinking water.[11] An extensive survey of the peer-reviewed literature was conducted using PubMed and Toxnet databases to find additional peer-reviewed published research results appearing in the literature since these documents were published.

## *3.2 Glyphosate Toxicity to Humans and Levels of Concern*

The herbicide glyphosate (N-(phosphonomethyl)glycine) is an organophosphorus compound. Unlike the more toxic organophosphorus insecticides, glyphosate is not an inhibitor of cholinesterase. It affects amino acid metabolism in plants and bacteria through a pathway that does not exist in humans or animals.

There are large amounts of data available on potential acute and chronic health effects related to human exposure to glyphosate, in contrast to the less widely used herbicide triclopyr—the other herbicide proposed for use by UCSF. The glyphosate data encompass a much larger variety of exposure scenarios and target populations, including farmers, applicators, and gardeners, and often include women and children. In contrast, triclopyr research focuses on short-term studies of male forestry workers exposed for three months or less per year. Most of the toxicity data used by US EPA for assessing risk to humans is from animal studies, which are summarized in Section 3.3.

In spite of the large quantity of glyphosate used and widespread human exposure, serious poisonings are rare, primarily because glyphosate is not well absorbed through the skin or by inhalation, the most common routes of exposure. The low absorption rate also accounts for the low to non-detectable levels found in the urine in biomonitoring studies. Most reported acute illnesses involve irritant contact effects on the skin and the eyes. Glyphosate is well absorbed when swallowed, and all the reports of serious illness and deaths are from accidental or suicidal ingestions.

There are fewer studies available of potential chronic health effects related to glyphosate. Some have shown an increased risk of cancer and adverse reproductive outcome in workers with the highest exposure. These risks are not especially relevant to the general public not involved in conducting herbicide applications. As opposed to workers, the general public will probably be exposed to low levels of glyphosate only a few times per year. Other factors to consider when assessing the risk of cancer and other chronic effects of glyphosate, even in highly exposed workers, are concurrent exposure to other pesticides, lack of direct exposure data, and the influence of other factors known to be related to the disease being studied.

As discussed below, because of the small number of reported cases, the findings in the reported studies do not suggest that glyphosate exposure is a major risk factor for cancer or adverse reproductive outcome. More precise studies and longer terms of exposure with a larger number of cases are needed to determine the risk more reliably.

There is only one epidemiological study of neurological disease and glyphosate, related to Parkinson's disease, in which no increase in risk was found. Since occupational herbicide exposure is a known risk factor for Parkinson's disease,[12] and glyphosate is one of the most widely used herbicides, further study would be necessary to confirm these findings.

The epidemiological studies of health outcomes in exposed populations of people that are presented in this section vary in their ability to distinguish statistically significant effects. Those with large study populations like the Agricultural Health Study provide the most definitive results, but even these studies will typically require followup to confirm the findings. Some of the studies presented here are confounded by factors such as exposures to multiple pesticides or suffer from poor study design. Some of the findings are not statistically significant. No definitive conclusions can be drawn from these studies, and further study would be required to clarify the results. These studies are included because even the non-statistically significant results may provide useful information necessary to better understand links between exposures and disease and also provide information on the strength of any associations.

## 3.2.1 Health Effects

The following health summary of the adverse health effects of glyphosate exposure in humans is based on data from scientific journals, state and federal regulatory agencies and other primary sources, cited herein.

#### *3.2.1.A Acute Effects—Skin*

Exposure to glyphosate formulations can cause skin irritation, and contact or allergic dermatitis. Most skin problems are of the irritant type. Severe skin burns are rare. Surfactants in formulated products, including polyoxyethyleneamine (POEA) and other inert ingredients, may cause or enhance the irritant properties of glyphosate.[13]

**SENSOR reports:** The following selected incidents are examples of skin injuries implicating glyphosate.

- After a 49-year-old woman was splashed with a glyphosate herbicide, her skin peeled and flaked for over three months. Michigan 2001-2003.
- A 20-year-old male in a warehouse store was stocking shelves when a bag of glyphosate-containing herbicide broke onto his arms, causing redness and irritation. Michigan 2005.
- A 58-year-old female licensed applicator wearing appropriate protective equipment developed redness of her face and neck a few hours after applying glyphosate; it was thought to be an allergic reaction. Washington 2004.
- A three-year-old boy developed skin symptoms while in a churchyard with a worker mowing the grass and applying glyphosate for spot treatment of weeds. The child reportedly followed the applicator around the churchyard. Washington 2004.

- A 23-year-old male landscaper assistant applying a weed control product with a hand sprayer, developed skin symptoms on his extremities. He was diagnosed with an apparent allergic reaction. Washington 2004.

Of 815 glyphosate-related calls to the Cal-EPA PISP over a 15-year period (1982-1997), 250 involved skin irritation (63 percent) without systemic symptoms.[77] In a case report, a 78-year-old woman developed extensive chemical burns on her trunk and legs caused by accidental contact with a glyphosate-surfactant formulation. The lesions healed in four weeks without scarring.

A study of 366 banana plantation workers in Panama found two glyphosate positive patch tests (among 37 tested), indicating allergic sensitivity.[14]

A case of occupational allergic photocontact dermatitis was thought to be from the inert ingredient benzisothiazolin-3-one[15, 16] in a glyphosate product.[17]

#### *3.2.1.B Acute Effects—Eyes*

Eye injury from glyphosate can result in redness, tearing, burning, conjunctivitis, and damage to the cornea. Spray mist can cause oral or nasal discomfort, an unpleasant taste in the mouth, tingling and throat irritation.

Of 1,513 glyphosate-related calls to a poison control center in the US from 1993 to 1997, transient eye symptoms occurred in 70 percent. Temporary injury occurred in two percent, one of which took more than two weeks to resolve. In no instance did exposure result in permanent change to the structure or function of the eye.[18]

**SENSOR reports:** The following selected incidents are examples of eye injuries implicating glyphosate.

- A female pesticide applicator for a lawn service company sprayed some glyphosate herbicide onto her face and eyes while fixing a pump. She had burning, and tearing of her eyes which were swollen shut for about a week. The tearing lasted almost a year. Michigan 2006.
- A 21 year-old man fixing a glyphosate sprayer without wearing gloves touched his eye, which became red, and he felt burning, dryness, and itch. He was diagnosed in an ER with a corneal abrasion. Michigan 2004.
- A 25 year-old male landscape employee wearing eye protection got glyphosate in his eye, requiring medical attention for corneal irritation. Washington 2004.
- A 19 year-old man applying glyphosate to the family garden had eye irritation and burning, which began about two hours after wind gusts blew spray onto his face. It resolved in 24 hours. Washington 2005.
- A 2 year-old boy sprayed himself in the face with a "ready to use" herbicide container at home. His mother immediately washed him off and ran water over his eyes for 3 min. His eye irritation resolved before he was taken in for a medical exam the next day. Washington 2002.
- A 45 year-old male home owner splashed a glyphosate product in his eye while applying it to his lawn. He was not wearing eye protection as recommended by the product label. He flushed his eye, but sought medical care for persistent irritation. Washington 2003.

- A 58 year-old male correctional officer was escorting an applicator spraying weeds on prison grounds when spray from the boom hit his face. He sought treatment for eye and respiratory symptoms. Washington 2001.

A study from New Zealand reported periorbital edema and chemosis (swelling of the conjunctiva, the tissue that lines the surface of the eye), and prolonged skin irritation related to glyphosate.[19]

#### *3.2.1.C Acute Effects—Asthma*

Exposure to pesticides can trigger or exacerbate asthma, induce bronchospasm, and increase bronchial hyperreactivity. Glyphosate has not been shown to be an independent risk factor for asthma, i.e. to cause asthma. There was one report in the SENSOR data of glyphosate triggering an attack in a woman with a known history of asthma.

- A 44 year-old woman was spraying glyphosate in her rose garden when a gust of wind blew into her face. She immediately became symptomatic, was put into a shower by her husband, became worse and was taken to the ER. She had a history of asthma and the label apparently had cautionary comments for people with that condition. Washington 2004.

#### *3.2.1.D Acute Effects—Systemic Poisoning*

Systemic poisoning occurs when a toxic chemical enters the blood stream and is carried throughout the body, adversely affecting internal organs and body systems. Since glyphosate is poorly absorbed through the skin and inhalation is not a major route of entry, adverse effects resulting in life-threatening illness and death are related to accidental or suicidal ingestion.

It is not always clear in reported cases whether concentrated or dilute formulations were ingested. Nor is the contribution of inert ingredients in the product usually reported; when inert ingredients are known, POEA and other surfactants are most often implicated. There were no fatalities from accidental ingestion in the reported cases, and all deaths were suicides.[20,21,22,23,24,25,26]

Ingestion of glyphosate products affects the upper gastrointestinal tract, resulting in erosion injury to the esophagus, stomach, and duodenum[27] and can cause severe laryngeal injury.[28] Swallowing more than 85 mL of the concentrated formulation is likely to cause significant toxicity in adults. Moderate symptoms were associated with swallowing 20 to 500 mL, mild symptoms with 5 to 150 mL, and no symptoms with 5 to 50 mL. The mean dose for those who died was 330 mL, and for the survivors 122 mL.[29] People older than 40 years of age who ingest more than 150 mL may be at the greatest risk of a fatal outcome.[30] The minimum lethal dose has not been established.

#### *3.2.1.E Chronic Health Effects—Cancer*

The EPA classified glyphosate as ‘Group E: Evidence of Non-Carcinogenicity for Humans’ in 1991. The ‘E’ group was used “for agents that show no evidence for carcinogenicity in at least two adequate animal tests in different species or in both adequate epidemiologic and animal studies.”[31] This classification system is no longer in use, but glyphosate will retain the older rating until EPA re-evaluates the chemical. See Section 2.2.6.A for more information on cancer classifications.

Since the 1991 EPA classification, there have been several epidemiological studies of glyphosate exposure as a risk factor for cancer in humans. Most of the studies are in men who use pesticides regularly—farmers or other applicators. Some of these studies show an increased risk of cancer in those with the highest exposure. These risks are unlikely to be relevant to consumers who are exposed to back yard amounts of glyphosate or less. Because the glyphosate applicators in these studies were also exposed to other pesticides and their direct exposure was not measured, it is uncertain if the cancer found in these workers is due to glyphosate, another pesticide, or perhaps the influence of some other factors related to cancer that were not included in the study.

As discussed below, because of the small number of reported cases, the findings in the reported studies do not mean that glyphosate exposure is a major risk factor for cancer and adverse reproductive outcome, only that more precise studies and longer terms of exposure with a larger number of cases are needed to determine whether or not the results are reliable.

**Sweden:** A case-control (retrospective) study conducted in Sweden from 1993 to 1995 reported a non-statistically significant 230 percent increase in risk (Odds Ratio, or OR = 2.3, Confidence Interval, or CI = 0.8–2.2) of non-Hodgkin lymphoma (NHL) associated with exposure to glyphosate.[32] See Section 2.2.7.E for more on statistical significance. The data are not particularly robust, with findings based on only four cases and three controls, and the data were not adjusted for concurrent exposure to other pesticides. In a multivariate analysis including exposure to both glyphosate and phenoxyacetic acid herbicides, a non-significant 580 percent increase was found for glyphosate (OR 5.8, CI 0.6–54). The study design and findings were criticized by scientists affiliated with the Monsanto Company, manufacturer of glyphosate.[33]

In 2002, the same Swedish investigators performed a pooled analysis of the NHL study described above, with the results from a previous 1998 case-control study of hairy cell leukemia, thought to be a variant or rare subtype of NHL.[34, 35] In the pooled analysis, a statistically significant 304 percent increase in risk (OR 3.04, CI 1.08–8.52) associated with glyphosate was found on univariate analysis (using only glyphosate exposure as a variable), but not on multivariate analysis (including glyphosate exposure plus other potential contributing factors). Increased risk was also found for a large number of other pesticides and occupational exposures.

Monsanto was also critical of this study, stating “the fact that virtually every tested factor proved positive—inconceivable biologically—speaks to a simpler interpretation, namely differential reporting by cases and controls”. [36] This differential memory of exposure in which people who are ill (cases) are much more likely to remember specific exposures than healthy people (controls) is known as ‘recall bias’.

In 2008, the same researchers published the results of a second retrospective case-control study conducted in Sweden between 1999 and 2002.[37] 910 male and female subjects aged 18 to 74 years with NHL and 1,016 controls were evaluated with regard to pesticide exposure as a risk factor. A statistically significant increase in risk [OR 2.02 (95% CI 1.10-3.71)] was associated with glyphosate exposure either individually or in combination with other herbicides, including phenoxyacetic acid herbicides. The risk factor increased [OR 2.36 (CI 1.04-5.37)] when exposure exceeded 10 days. Because exposures were only assessed retrospectively and

qualitatively by questionnaire, and not specific for glyphosate exposure, these results by themselves are limited in value for determining causation. Nevertheless, these results combined with the results of other comparable studies summarized in this section do raise a concern regarding the potential for exposure to glyphosate formulations (alone or in combination with other pesticides) to contribute to an increased risk of NHL in humans.

**Canada:** In 2001, Canadian investigators reported the findings of a much larger case-control study of 571 new cases of NHL among men in a diversity of occupations, conducted from 1991 to 1994 in six provinces (British Columbia, Manitoba, Ontario, Quebec, and Saskatchewan). Based on "ever" versus "never" exposed to glyphosate, a non-significant 20 percent increase in risk of NHL was found (Risk Ratio, or RR = 1.20, CI 0.83–1.74), based on 51 cases and 133 controls. A significant dose-response was found with a 212 percent increase in risk (RR 2.12, CI 1.20–3.73) among those exposed to glyphosate at least ten days a year compared to those never exposed, based on 23 cases and 36 controls.[38]

**NIH:** In 2003, pooled data from three National Institutes of Health (NIH) sponsored case-control studies of farmers in Iowa, Kansas, Minnesota and Nebraska, found a significant 210 percent increase in risk (OR 2.1, CI 1.1–4.0) of NHL associated with ever having used glyphosate, after adjusting for exposure to other pesticides.[39]

**Agricultural Health Study:** In 2001, the results of an investigation of glyphosate and cancer in The Agricultural Health Study (AHS) cohort was reported. The AHS, a prospective study of a 1993 to 1997 cohort of 57,311 private (farmer) and commercial pesticide applicators in Iowa and North Carolina, is sponsored by the Occupational Epidemiology Branch of the NIH's National Cancer Institute.[40]

Among the 40,376 applicators who ever used glyphosate and 13,280 who never used it, 92 cases of NHL were found. No associations were found between NHL and glyphosate exposure, based on cumulative days and intensity of exposure. Nor were any associations found when comparing the highest with the lowest quintile of exposure, or when comparing ever versus never exposed, or by state of residence.

The study did suggest an association between glyphosate and another cancer—multiple myeloma (cancer of plasma cells in the bone marrow). Although the myeloma cases were sparsely distributed among the participants, the highest increased risks were observed at the highest exposure levels. A significant 660 percent increase was found in the upper quartile versus never exposed (RR 6.6, CI 1.4–30.6) with a significant trend across quartiles ($p = 0.01$). Risk ratios were elevated, but not statistically significant, across cumulative days of low (RR 2.3, CI 0.6–8.9) and medium exposure (RR 2.6, CI 0.6–11.5), and borderline significant in the high exposure category (RR 4.4, CI 1.0–20.2), with a non-significant trend ($p = 0.09$). Elevated risks were found in both Iowa (RR 2.6) and North Carolina (RR 2.7).

There were only 19 myeloma cases, and the authors discussed the possibility that the association could be related to bias in the analysis. The number of subjects in the entire group with exposure to glyphosate (unadjusted) was larger than the number of subjects in the group that considered other variables in addition to glyphosate exposure (adjusted). A positive association was found

only among the smaller group. Both groups were similar in their use of glyphosate (75.9 percent versus 74.5 percent).

There was no increase in the risk of 'all cancers combined'. The 30 to 60 percent elevated risk for colon, rectal, kidney, and bladder cancer was not statistically significant. Elevated risks of leukemia and pancreatic cancer were observed only for the moderate exposure groups but no increase was found in the highest exposure group.

A significant trend for decreased risk of lung cancer was suggested for the highest exposure group compared to the other exposure, but this trend was not found with comparison to the never exposed group.

In spite of the cohort's size, the large number of participants reporting glyphosate use, and the prospective design, the authors acknowledge their data have limitations. The number of specific cancers occurring during the follow-up period was small; and the analyses provide no information on the timing of pesticide use in relation to disease. This limits defining latency periods (the time from first exposure to the development of cancer) or effects resulting from glyphosate exposure at different ages.[41]

A major difficulty in interpreting results of the available cancer studies is lack of data on direct exposure and concurrent exposure to other pesticides in addition to glyphosate. Without additional better-designed studies and future updates of the important AHS cohort data, whether or not glyphosate poses a significant risk of cancer in humans remains an open question.

**Columbia:** Bolognesi et al. (2009)[42] measured the frequency of micronuclei in lymphocytes (a technique used as a biomarker of chromosomal damage and genome stability) in blood samples taken from 274 men and women residing and/or working in five Colombian regions, each characterized by different exposures to formulated glyphosate and other pesticides. For the purposes of this study, each subject served as his/her own control by having a baseline measurement taken before pesticide spraying occurred followed by a second measurement after five days and then a third measurement four months after spraying. The authors stated that they accounted for confounding variables by obtaining information from each subject about other causes of chromosomal damage including smoking, drug use, other pollutants, infections, x-rays, and other factors.

The results indicate that in all four regions where pesticides are used, mean baseline micronuclei frequency in workers and residents is significantly elevated (by as much as three-fold) over subjects who reside/work in the fifth region where no pesticides are applied. The highest mean frequencies of micronuclei were measured in subjects in a region where no aerial application of formulated glyphosate occurred and in a second region where formulated glyphosate is applied by aerial spraying sugarcane but at 30% of the levels used in the other two regions where glyphosate is aerially applied. Following formulated glyphosate spraying there is a small and transient increase in the frequency of micronuclei but these increases appear not to be dose-related. It should also be noted that some glyphosate formulations available for use in Colombia are not available in California. Overall, these results indicate that pesticide exposure in general

increases the frequency of chromosomal damage in workers or residents. The contribution of glyphosate, while suggestive is not certain.

**Ecuador:** The comet assay was used to study 24 people (23 females) age 17 to 55 years old (mean age 38 ± SD 12.2) with bystander exposure to aerial spray of a glyphosate product being used in Ecuador for drug crop eradication.[43] The comet assay tests for DNA damage in individual cells by using electrophoresis and fluorescence microscopy. Undamaged DNA retains a compact, highly organized association with matrix proteins in the nucleus. This structure is essential for cell division and proper protein coding. When damage occurs, this configuration is disrupted, creating DNA fragments of varying sizes and structures. These fragments are of non-uniform length and move through an electrically charged gel (technique known as electrophoresis) at varying speeds, creating "lines" or "tails" on the gels. Cells containing greater levels of DNA strand break damage generate comets with more intense 'tails.' Twenty-one unexposed controls were included (18 females) including four teenagers, and one person aged 71 (mean age 33 ± SD 15). The blood samples were not drawn until two weeks to two months after exposure. The authors state that neither the cases nor the controls smoked tobacco, drank alcohol, took non-prescription drugs or had been exposed to other pesticides. Comet length of 35.5 μ m in those exposed was greater than the 25.94 μm in the controls. It is difficult to interpret this study, since the authors do not provide sufficient information on how the study participants were selected, and did not apply any test of statistical significance.

#### *3.2.1.F Chronic Health Effects—Rhinitis*

Rhinitis is a common chronic condition in which the nasal passages are irritated and inflamed, which impacts the ability to sleep, quality of life, cognitive function, and workplace productivity. Rhinitis is also linked to the development of asthma and worsening asthma severity. Cross-sectional data on rhinitis from the Agricultural Health Study and pesticide use from 21,958 Iowa and North Carolina farmers were used to evaluate pesticide predictors of rhinitis. Sixty-seven percent of farmers reported current rhinitis and 39% reported three or more rhinitis episodes. Glyphosate [OR = 1.09, 95% CI = 1.05–1.13] was associated with current rhinitis and increased rhinitis episodes. The authors concluded that specific pesticides, including glyphosate, contribute to rhinitis in farmers.[44]

#### *3.2.1.G Reproductive Effects*

There are no human studies of glyphosate as an independent risk factor for adverse reproductive health effects; however, animal toxicology data do not indicate that glyphosate is a reproductive toxicant (see Section 3.3.1.C). Three reports of reproductive outcome related to glyphosate exposure are from the Ontario Farm Family Health Study (OFFHS), one on spontaneous abortion [45], one on fecundability (fertility) [46], and another on paternally mediated effects.[47] A discussion of these studies in which glyphosate exposure was investigated along with several other pesticides follows.

The OFFHS is a retrospective study of a 1991 to 1992 cohort of farmers and their spouses (women 44 years of age or younger) conducted in Ontario, Canada from 1991 to 1992. Eligible participants lived year round on a farm, and at least one member of the couple worked on the farm. Questionnaire information (by mail and telephone for non-respondents) was collected on

current pesticide use and practices on the farm and in the yard for the past five years, and a lifetime reproductive history.

Included in the data collection and analyses were eight other pesticides besides glyphosate (atrazine, captan, carbaryl, cyanazine, 2,4-D, 2,4-DB, dicamba and MCPA); four chemical groups (phenoxy acetic acids, triazines, organophosphates, and thiocarbamates); and four usage groups (herbicides, fungicides, insecticides and miscellaneous). Only results related to glyphosate are discussed in this summary.

**Spontaneous Abortions:** Women were asked to recall all spontaneous abortions, and the number of weeks into the pregnancy when it occurred (based on the last menstrual period). Glyphosate exposure was asked about in three time periods: pre-conception (three months before and up to the month of conception), early post-conception (less than 12 weeks gestation) and late post-conception (12 to 19 weeks gestation).

In the OFFHS cohort, 395 spontaneous abortions among 2,110 women with 3,936 pregnancies were found (10%). For late abortions, pre-conception exposure to glyphosate was associated with a borderline significant 170 percent increase in risk (OR 1.7, CI 1.0–2). See Section 2.2.7.E for more on statistical significance. Among older women exposed to glyphosate, there was a non-significant 320 percent increase in risk (OR 3.2, CI 0.8–23.0) compared to unexposed women of the same age. The authors did not adjust the data for other factors related to early fetal loss, including maternal age, smoking, history of previous spontaneous abortion, and exposure to other pesticides.[45]

**Fecundability:** Fecundibility related to glyphosate exposure was investigated in 2,012 planned pregnancies among 1,048 couples in the OFFHS cohort. Exposure was defined as glyphosate use on the farm during the months of trying to conceive or at any time during the prior two months. Approximately one-third of conceptions had occurred more than ten years before the questionnaire date. The data were adjusted for maternal and paternal age, alcohol use, smoking, and prior oral contraceptive use.

A non-significant 39 percent decrease in conditional fecundability (Fecundity Ratio, or FR = 0.61, CI 0.3–1.26) related to women's glyphosate exposure, regardless of men's was found based on 32 cases. Men's glyphosate exposure showed a significant 30 percent increase in fecundability (FR 1.30, CI 1.07–1.56) based on 175 cases.

In addition to recall bias (*vide supra*) the authors acknowledge that selection bias is a problem with this study, since only women who ultimately became pregnant were included, and "more severely subfecund couples who may have become pregnant by the time of data collection are underrepresented". This would bias the study towards the null, finding no effect, "even if pesticide exposure is associated with sterility or extremely long prolonged time to pregnancy."[46]

**Paternally mediated effects:** Spontaneous abortion, preterm birth (before 37 weeks), small for gestational age (birth weight below the 10th percentile) and sex ratio (proportion of males among singleton births), were investigated in the offspring of men with direct exposure to pesticides

(mixing and applying) in the OFFHS cohort. In a total of 3,984 pregnancies (1,548 live births) there were 375 spontaneous abortions, 276 small for gestational ages, and 128 pre-term births.

Of the small number who had glyphosate exposure, there was a non-significant 50 percent increase in risk of spontaneous abortion (OR 1.5, CI 0.8-2.7) based on 17 cases; a non-significant 240 percent increase in preterm delivery (OR 2.4, CI 0.8-7.9) based on five cases; and a non-significant 20 percent decrease in risk of small for gestation age (OR 0.8, CI 0.2-2.3) based on 5 cases. There was no association with sex ratio.[47]

**Birth Defects:** An ecological study in California of neural tube defects (NTD) and maternal residence within 1,000 meters of pesticide applications around the month of conception was investigated in two birth cohorts, one in 1987, and another from 1989 to 1991. A geographic model linking California Pesticide Use Reports (PUR) of 59 different pesticides and land-use survey maps was used in the data analysis.[48]

It is noted that the pesticide use reporting system on which the study was based did not require mandatory reporting of all pesticide use until 1990, and the new system was not fully operational until the 1992 reporting year.

Of 315 NTD cases and 652 controls delivered in 1987, and 613 cases and 611 controls delivered between 1989 and 1991 in all California counties, there were 45 cases (4.8 percent) and 33 controls (2.6 percent) exposed to glyphosate. There was a non-significant 40 percent increase in risk (OR 1.4, CI 0.8, 2.5) of NTDs when controlling for exposure to other pesticides.[48]

Neural tube defects (NTDs) include anencephaly in which the infant is born without the forebrain and cranium, and the more common and less severe spina bifida in which herniation of spinal cord contents occurs due to imperfect formation of the vertebrae. A deficiency of the micronutrient folic acid (folate) is the biggest known risk factor for NTDs and perinatal supplementation (including enrichment of flour) has resulted in a marked reduction in this defect in the United States and throughout the world.[49]

In a 2002 Minnesota study of licensed pesticide applicators and their families, a statistically significant association emerged between glyphosate use by parents and neurobehavioral defects (ADD/ADHD) in children, with an odds ratio of 3.6 (CI 1.3–9.6).[50] The authors of this study classify the association as “tentative” and note that:

> *In vitro studies by our group show that this product was not genotoxic in the micronucleus assay and did not have significant pseudoestrogenic effects in MCF-7 cells. In a recent review of the toxicology of glyphosphate, little if any evidence of neurotoxicity was noted other than by intentional ingestion.*

Direct exposure data was not available in any of the above studies, and there was simultaneous exposure to other pesticides in addition to glyphosate. Based on these findings, it is an open question whether or not glyphosate poses a significant potential risk of reproductive harm to humans.

#### *3.2.1.H Chronic Health Effects—Neurological*

There are no reports of permanent neurological effects related to glyphosate exposure except for a 2001 case report from Brazil. A 54-year old man with extensive overexposure to a glyphosate product while spraying his garden, developed severe eye effects and skin burns which resolved. One month later he developed hand tremors, and two years later was diagnosed with Parkinsonism, and responded to treatment with Levodopa.[51] It is most likely this was coincidental, and no further cases of Parkinson's or other neurological disease related to glyphosate have been reported.

In a recent study of self-reported Parkinson's disease in the Agricultural Health Study cohort, no associations were found related to glyphosate exposure for either prevalent (OR 1.0, CI 0.6-1.7), or incident cases (OR 1.1, CI 0.6–2.0) of the disease.[52]

#### *3.2.1.I Levels of Concern for Humans*

The acute and chronic EPA RfD of 2.0 mg/kg-day is used as the toxicity reference value (TRV) for both acute and chronic exposure scenarios. The NOAEL of 175 mg/kg-day is based on a developmental toxicity study in rabbits, where early maternal mortality was observed at the next highest dose of 350 mg/kg-day (see Section 3.3 below). This NOAEL was divided by both intra- and inter-species uncertainty factors of 10 to give a value of 2.0 mg/kg-day for adults and children.

### 3.2.2 Routes of Exposure

Potential human exposure to glyphosate is through skin absorption, inhalation, ingestion or the eye. The US Environmental Protection Agency (EPA) classifies glyphosate as moderately acutely toxic (Toxicity Class II), and a mild irritant. The oral reference dose (RfD) determined by the EPA that is not likely to cause harmful effects during a lifetime for both adults and children is 2 mg/kg-day.[6]

**Skin:** As with most pesticides, the skin is the major route of exposure to glyphosate, but penetration and absorption are low.

In a study using human autopsy samples, Roundup was applied in 1:20 to 1:32 dilutions to thigh skin. Less than two percent of the applied glyphosate penetrated the skin. Twelve hours after the treatment, soap and water removed 89.6 percent of the applied dose, and water alone 83.6 percent.[53]

An *in vitro* study of glyphosate penetration into human skin found only 1.42 percent was absorbed from water. The amount absorbed decreased to 0.74 percent if the glyphosate was added to cotton sheets and immediately placed on the skin. If the cotton sheets were dried for one or two days and then applied to the skin, absorption was much lower—0.08 percent. Chemicals are absorbed more rapidly and in greater amounts if the skin is damp or sweaty. When the investigators wet the two-day dried cotton sheet with water to simulate sweating, the amount absorbed rose from 0.08 to 0.36 percent, an increase of 350 percent.[54]

In a study of 346 human volunteers, 0.1 milliliters (mL) of 41 percent glyphosate was applied to abraded and un-abraded skin of the back, and compared with applications of liquid cleaner, baby

shampoo, and liquid dishwashing detergent. In those with un-abraded skin, erythema (redness) was found in only one of 24 subjects (4 percent) after 24 hours. Of 24 subjects with abraded skin, erythema was present in ten (42 percent), absent in ten, and equivocal in four (16 percent). Forty-eight hours after application, glyphosate erythema was similar to that from the liquid cleaner and the dishwashing liquid.

In the same investigation, glyphosate and baby shampoo were less irritating than either the liquid cleaner or dishwashing liquid in a 21 day cumulative irritancy assay. In a photoirritation and photosensitization study, undiluted Roundup was applied to abraded skin of the upper arm for 24 hours with UVA light applied for 45 minutes. No evidence of skin sensitization (allergic reaction) was found.[55]

**Eyes:** Because blood vessels in the eye are close to the surface, pesticides can enter the bloodstream through the eye and cause poisoning, but this is rare, and is not found with glyphosate. Most cases of eye injuries from glyphosate are from direct contact, or from splashes and spills.

**Inhalation:** Glyphosate has a very low vapor pressure ($1.6 \times 10^{-8}$ mm Hg), and inhalation is not a major route of exposure. A 1995 California Department of Pesticide Regulation (DPR) study of forestry workers applying glyphosate found that inhalation exposure accounted for less than 0.2 percent of exposure.[56] A study of forest workers in Finland found that exposure to glyphosate through spray droplets in the breathing zone was low, with the highest value being 15.7 micrograms/$m^3$.[57] No Occupational Health and Safety Administration (OSHA) permissible exposure limit (PEL) or ACGIH threshold limit value (TLV) in air has been set for glyphosate. OSHA has set an arbitrary target level of 1 mg/per cubic meter ($m^3$).[58]

**Ingestion:** Glyphosate is absorbed from the gastrointestinal tract. At doses greater than 10 mg/mL, it significantly disrupts the barrier properties of cultured intestinal cells.[59] This route of absorption is important in intentional and accidental ingestions, which are discussed in more detail on page 3-9.

### 3.2.3 Biomonitoring Studies

Human exposure to chemicals in the workplace or environment can be assessed by measuring residues of the chemical or its metabolites in biological fluids (such as urine and blood) or by isolating human cells and determining whether the chemical has caused alterations in genetic material such as DNA. This method has been termed biological monitoring or "biomonitoring." Most biomonitoring studies of glyphosate report low to non-detectable levels in the urine of farmers, forestry and landscape workers who handle glyphosate. The highest exposures were less than 0.02 percent of US EPA's Reference Dose (RfD) and average exposure was less than 0.005 percent of the RfD.

Glyphosate is excreted unchanged in the urine, and can be detected at less than one part per billion (ppb).[60, 61] One ppb is equivalent to one millionth of a gram in one liter of urine, and can also be expressed as nanograms per microliter (ng/μL) or micrograms per liter (μg/L).

Glyphosate does not persist in body tissues and fluids as DDT and other persistent pesticides do. The amounts found are a measure of recent exposure at the time of sampling, and cannot be used to ascertain or predict past or future exposures over time. Testing biological samples for glyphosate is not available in standard medical care facilities.

**NIOSH:** In 2001, NIOSH sponsored a study investigating take-home pesticide exposure in farm and non-farm families in Iowa. Urine samples were collected from 47 fathers, 48 mothers and 118 children on two occasions approximately one month apart. The adjusted geometric mean (GM) of glyphosate was similar between farm and non-farm groups for the adults. Glyphosate levels in children (66 farm, 52 non-farm) were higher in the non-farm group. The amounts found were similar for boys and girls, with the highest estimated dose of 0.34 µg/kg-day.[62,63] US EPA estimate of NOAEL in laboratory test animals is 175 mg/kg-day, and the oral exposure reference dose (RfD) is 2 mg/kg-day.

**Forestry:** Urinary glyphosate levels were measured in 15 forestry workers, the day prior to, the day of and three days following application of the original Roundup. For 11 workers (73 percent), no glyphosate was detected (LOD 10 ppb) on any day; four (27 percent) had detectable levels only on the day of application. The highest individual amount found was 14 ppb. The systemic dose was estimated to be 0.0006 mg/kg body weight.[64]

The USFS has summarized in detail several biomonitoring studies for glyphosate on which the general worker exposure rates were based,[5] in milligram of pesticide per kilogram of body weight per pound of pesticide applied for directed foliar applications using a backpack sprayer. The USFS determine a default worker exposure rate for this application method of 0.003 mg/kg bw per lb applied, with a range of 0.0003 to 0.01 mg/kg bw per lb applied. The study details are given in the USFS glyphosate risk assessment, with highlights presented here.

Jauhiainen *et al.* (1991),[65] conducted urinary biomonitoring on five forestry workers and five controls before, during and after clearing trees using brush saws equipped with pressurized sprayers. Urine samples (not total daily urine) were collected at the end of each work day for one week during the application period, and one sample was taken 3 weeks after the applications. Only one sample was found to containing glyphosate over the limit of detection, at 0.085 µg/mL urine. Assuming body weight of 70 kg and an approximate urinary output 2.0 L/day, the absorbed dose was calculated to be 119 µg.

Lavy *et al.* (1992)[66] studied nursery workers at two tree nurseries in Arkansas applying Roundup to small weeds in a nursery bed using a shielded spray nozzle to protect desirable plants nearby. Total urine excreted over a 12-week period was collected and tested for glyphosate in workers employed as applicators, weeders, and scouts. No positive urine samples were found (LOD 0.01 µg/mL). High rainfall, irrigation as needed, normal field dissipation and worker training were cited as contributing factors for the low exposure and absorption.

Middendorf *et al.* (1993)[67] studied 15 backpack spray workers applying fairly dilute (2.3%) solutions of Roundup, reporting urinary excretion, pounds applied, body weight, and deposition at three different application sites. The average exposure rate for all workers was approximately 0.00032 mg/kg bw per lb applied with a range of 0.00013-0.001 mg/kg bw per lb applied.

Another study by Lavy *et al.* (1987)[68] compared exposures experienced by workers using different application techniques and with different safety gear. Although glyphosate was not one of the pesticides evaluated in this experiment, the data are still relevant for comparing exposures from different application techniques. In this study, four crews of 20 workers in each crew applied 2,4-D, dichlorprop or picloram using a backpack sprayer, injection bar, Hypohatchet, or a hack-and-squirt method (comparable to cut stump techniques—see Chapter 2, Section 2.1.1). Total urine output was measured under two sets of conditions: 1) Normal work habits and no special clothing, and 2) Workers asked to "take all feasible precautions to prevent herbicide exposure and to wash immediately if they come into contact with the chemical," and issued new leather gloves and boots prior to working. On average, backpack spray workers were exposed to approximately 10 times more herbicide than workers using injection bar or hack-and-squirt application techniques. The use of greater precautions led to significantly lower exposures for all applicators except backpack spray workers.

**Farm Family Exposure Study (FFES):** The Farm Family Exposure Study is a biomonitoring study of 45 farm families in Minnesota and 50 families in South Carolina, conducted by the University of Minnesota and co-sponsored by CropLife America, a trade association for agricultural chemical companies (Bayer, Dow, DuPont, FMC, Monsanto, and Syngenta) and the American Chemistry Council.

To qualify for inclusion in the study, the families had to live on farms and apply one of the study pesticides (2,4-D, chlorpyrifos (Lorsban™), or glyphosate) to at least 10 acres of farmland within one mile of the family residence. Participating family members had to include the applicator, spouse and at least one child age 4 to 17. Each participant had to agree to collect urine specimens 24 hours a day for five days. Monsanto's Environmental Sciences Research Laboratory did the glyphosate analyses, which were confirmed by the Centers for Disease Control.[69,,70]

Glyphosate levels for farmers ranged from < 1 ppb (LOD) to 233 ppb, with a geometric mean of 3.2 ppb. There were large differences between South Carolina (SC) and Minnesota (MN) farmers. Detectable levels of glyphosate were found in 87 percent of SC farmers with a GM of 7.9 ppb, versus 36 percent in MN, with a GM of 1.4 ppb. Only 43 percent of SC farmers wore gloves when handling glyphosate, versus 96 percent in MN.

Spouses had lower urine pesticide levels than applicators or children. There was no correlation between urinary levels for spouses and the distance between the house and the treated field. Of nine children with detectable levels in their urine, eight assisted or were present for the pesticide mixing or application, and all were from SC. The highest level for a child of 29 ppb, was in a teenage boy who actively helped his father with the mixing and application. The boy's father, who did not wear gloves and spent long periods of time repairing a leaking boom sprayer, had the highest level among applicators.

The maximum systemic dose for farmer applicators was estimated to be 0.004 mg/kg, with a geometric mean systemic dose of 0.0001 mg/kg. Maximum systemic dose estimates for spouses and children were 0.00004 mg/kg.[71]

### 3.2.4 Pesticide Illness Reports

In pesticide poisoning surveillance systems, less than one percent to six percent of reports are related to glyphosate, most of low to mild severity involving the skin and eyes without systemic illness. All serious illness and deaths were from accidental and suicidal ingestion. There are about 100 different formulations of glyphosate, ranging from 41 percent concentrates to less than 1 percent dilute products. In many (perhaps most) incidents, the actual ingredients involved are not known, and it may be difficult to impossible for the treating physician or other health care provider to obtain the required information at the time the patient presents. See Chapter 2, Section 2.2.4 for general information on pesticide poisoning surveillance systems.

**Toxic Exposure Surveillance System (TESS):** Table 3-1 summarizes glyphosate-related TESS data from 2002 (the first year glyphosate cases were listed separately) to 2006. The data represent contact with a poison control center, usually by telephone, regarding a potential poisoning problem, and does not mean that poisoning or illness definitely occurred. This is reflected in the combined percentage of 'None' and 'Minor' adverse outcomes shown in the table. For glyphosate, major outcomes are those related to accidental and suicidal ingestion. Outcomes are not know for all calls to the center, and the data in the table are based on cases for which follow up information was known, usually because of treatment in a medical care facility.

**Table 3-1: Calls to US Poison Control Centers Related to Glyphosate Exposure 2002 to 2006**

| | | Age | | | Causation | | | Adverse Outcome | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Total Cases | < 6 | 6-19 | >19 | Unintentional | Intentional | Other | None | Minor | None + Minor | Mod | Major | Death |
| 2006 | 4,496 | 1,133 | 321 | 2,251 | 3,901 | 51 | 30 | 920 | 1,111 | (45%) | 76 | 9 | 4 |
| 2005 | 4,679 | 1,245 | 378 | 3,017 | 4,380 | 62 | 24 | 1,085 | 1,159 | (48%) | 126 | 8 | 2 |
| 2004 | 4,425 | 1,162 | 360 | 2,872 | 4,146 | 59 | 18 | 1,024 | 1,154 | (49%) | 91 | 6 | 1 |
| 2003 | 4,420 | 1,157 | 340 | 2,875 | 4,109 | 57 | 33 | 1,059 | 1,167 | (50%) | 104 | 5 | 4 |
| 2002 | 4,472 | 1,217 | 397 | 2,814 | 4,191 | 43 | 20 | 1,087 | 1,144 | (49%) | 104 | 5 | 1 |

*Data source:* Poison Control Centers, reference 72.

**SENSOR**: In a summary of SENSOR occupational pesticide cases between 1998 and 1999, glyphosate accounted for 24 reports (2.4 percent), most of which were of low severity.[73] A survey using SENSOR data of young people 15 to 17 years of age, found a total of 531 acute occupational pesticide related illnesses (428 identified by TESS and 103 by eight state agencies). Glyphosate was implicated in 33 cases (6.2 percent).[74]

A survey using SENSOR and Cal-EPA data on retail employees 15 to 64 years old, found a total of 287 cases of acute pesticide related illnesses from 1998 to 2004. Seven were glyphosate-related (2.2 percent), four of low severity and three of moderate severity. The sectors with the highest rates were farm supply, hardware, and garden stores.[75]

**California PISP Data:** Table 3-2 shows the number of "definite, probable, and possible" glyphosate-related illnesses reported to the PISP from 1997 (the first year glyphosate cases were

listed separately) to 2006. The total number of cases is very small, from 0.93 to 2.3 percent of the total over the 10 year period. Most of the cases were of low to mild severity. There were no fatalities.[76] A survey of 815 glyphosate related calls to the Cal-EPA PISP over a 15 year period (1982 to 1997), found that 399 (49 percent) involved topical irritation of the eye without systemic symptoms.[77]

**Iowa:** In Iowa, Roundup was named in pesticide incident reports in 13 of 204 incidents (6.3 percent) in 2002, in 12 of 257 (4.7 percent), in 2004, and in 15 of 471 in 2005 (3.2 percent), of which 87.8 percent were telephone calls from homes.[78]

**Washington:** In Washington, 28 total incidents were reported in agricultural workers, two from Roundup (7.1 percent) in 2001–2003. Of 36 incidents reported in 2005, six involved Roundup (16.6 percent). In 2004, 32 percent (133) involved exposure to glyphosate.[79]

**Michigan:** Michigan did not report summary data by specific pesticide. Selected incidents described in the reports are included in the "Acute Effects" section below.[80]

**Table 3-2: Glyphosate-related Illnesses Reported by California Physicians To the Pesticide Incident Surveillance Program (PISP), 1997 to 2006**

| | Total Reported Pesticide Cases | | Glyphosate Cases | | | | |
|---|---|---|---|---|---|---|---|
| | | | Systemic/Respiratory | | Local/Topical | | |
| Year | Definite/Probable | Possible | Definite/Probable | Possible | Definite/Probable | Possible | Total (%) |
| 2006 | 454 | 84 | 0 | 0 | 4 | 1 | 5 (0.93) |
| 2005 | 767 | 144 | 1 | 2 | 5 | 4 | 12 (1.3) |
| 2004 | 552 | 276 | 2 | 7 | 7 | 1 | 17 (2.1) |
| 2003 | 614 | 188 | 0 | 0 | 5 | 5 | 10 (2.1) |
| 2002 | 1,025 | 291 | 4 | 8 | 5 | 2 | 19 (1.4) |
| 2001 | 430 | 186 | 0 | 4 | 7 | 2 | 13 (2.1) |
| 2000 | 637 | 256 | 2 | 3 | 11 | 3 | 19 (2.1) |
| 1999 | 830 | 371 | 6 | 3 | 8 | 4 | 21 (1.7) |
| 1998 | 621 | 377 | 2 | 6 | 6 | 9 | 23 (2.3) |
| 1997 | 892 | 427 | 0 | 4 | 11 | 6 | 21 (1.6) |

*Data source:* CA DPR Pesticide Illness Surveillance Program, reference 81.

**Australia:** The Victorian Poisons Information Centre in Australia reported 1,235 glyphosate-related calls among a total of 136,508 (0.9 percent) from 1998 to 2002. Ingestions accounted for 521 (42.2 percent).[82]

**Italy:** Of 872 agricultural pesticide poisonings referred to the poison control centre of Milan from 2000 to 2001, 53 (6.1 percent) involved glyphosate.[83]

## 3.3 Glyphosate Toxicity to Animals and Plants and Levels of Concern

This section summarizes glyphosate toxicity to nine taxa groups, including mammals, birds, fish, amphibians, terrestrial and aquatic invertebrates, terrestrial and aquatic plants, and soil microorganisms. Because glyphosate has been used extensively in the United States since 1974, there is a great deal of information about this chemical. The studies most relevant to the current project are discussed in detail. This document focuses on the information necessary to assess the potential risks of glyphosate use in the current project. Although there are still questions remaining about the sub-lethal effects of glyphosate, the bulk of the data suggests that glyphosate without the POEA surfactant is rarely more than moderately acutely toxic to any of the nine taxa groups.

For glyphosate, there are more studies available than can reasonably be summarized in this risk assessment. In 2003, the USFS performed a risk assessment for forestry use of glyphosate. Assuming that the USFS report did a thorough job of reporting toxicological studies up to 2003, the studies from that report are not included here. A literature search was done for the period between 2003-2008 and additional relevant work was included. The most relevant data from the EPA's Ecotox database were summarized in the text. Additional information can be found in the USFS risk assessment.[5] In addition, the records in EPA's Ecotox database were compared to the studies in the combined USFS report and literature search. The goal of the comparison was to assure that no biases were present in the studies that were included in this risk assessment.

The TRVs used in this risk assessment were adjusted downward when additional data were available indicating toxicity at concentrations below the USFS TRV, or when only $LC_{50}$ values were available instead of NOECs. The adjustment employed was to divide the $LC_{50}$ by ten for terrestrial species or 20 for aquatic species, based on EPA's standard practice for endangered species effects determinations.[8]

Levels of concern for glyphosate are also summarized in this section, with Table 3-8 presenting the toxicity reference values (TRVs) selected for this risk assessment and the USFS TRVs for comparison.

Aquatic species have different tolerances for technical grade glyphosate versus formulated products (like Roundup). Although the distinction between glyphosate and formulated products is somewhat less important for terrestrial wildlife, every effort was made to find toxicity endpoints that refer to glyphosate alone.

### 3.3.1 Mammals

Most information on the toxicity of glyphosate to mammals is derived from studies conducted on laboratory animals for registration purposes. Many of these studies are required by EPA as part of the pesticide registration process, primarily to evaluate the potential toxicity of the chemical to humans. Sources of the data are the CA OEHHA glyphosate review,[11] the US EPA RED,[6] an updated US EPA risk assessment,[7] the WHO evaluation,[10] and the USFS risk assessment.[5]

Additional recent peer-reviewed studies are also discussed in this section. Laboratory animal test data are summarized in Tables 3-3 to 3-6.

In general, glyphosate is poorly absorbed by mammals and has low acute toxicity. Glyphosate formulated with surfactants is typically 5–10 times more toxic than glyphosate alone. Long-term exposures in rats caused salivary gland lesions, reduced body weights and reduced organ weights. There is some conflicting evidence on the occurrence of unilateral renal tubular dilation in male rats on which the older US EPA Integrated Risk Information System (IRIS) reference dose is based, and a single study found reduced sperm quality on exposure to glyphosate. There is no evidence of low-dose endocrine disrupting effects for glyphosate, but some evidence that Roundup (a formulated glyphosate product with POEA as the added surfactant) may have endocrine-disrupting effects. Glyphosate was also not found to cause neurotoxicity, developmental, or immune system toxicity. The chronic reference NOAEL for mammals of 500 mg/kg-day is based on soft stools, decreased body weight gain, and food consumption at the next higher dose of 1,500 mg/kg-day. Because of low acute toxicity, no acute NOAEL was established by EPA, so the value of 500 mg/kg-day was used as the comparison toxicity reference value (TRV) for all glyphosate exposures.

Tumors were observed at various sites in some of the high-dose and intermediate-dose animals in chronic studies. However, results did not always follow a dose-response curve, and/or were not significant relative to historical control data. The weight of the evidence supports US EPA's classification of glyphosate as "E—Evidence of non-carcinogenicity for humans."

#### *3.3.1.A Metabolism and Pharmacokinetics of Glyphosate*

Glyphosate is poorly absorbed in mammals and is excreted largely unchanged. The lack of significant absorption is a contributing factor to the low toxicity observed for glyphosate.

When Sprague-Dawley rats were given a single dose of either 10 mg/kg or 1,000 mg/kg of $^{14}$C-labeled glyphosate, 97.5% of the administered dose was excreted in the urine and feces as the parent compound.[6] The timing of elimination is biphasic, with an excretion half-life for the first phase of 5.9–6.2 hours and for the second phase 79–106 hours.[84] The metabolite aminomethylphosphonic acid (AMPA) was found in the urine at concentrations representing less than 1% of the total glyphosate dose, and less than 1% of the absorbed dose remained in tissues and organs, primarily in bone. A second study with $^{14}$C-labeled glyphosate determined that less than 0.01% of the administered dose reaches the bone marrow, with an excretion half-life from bone marrow of 4–8 hours.[6] The magnitude of the dose (10 mg *vs.* 1,000 mg) did not significantly change the metabolism, distribution or excretion of glyphosate.

An NTP study where male rats were dosed by gavage with $^{14}$C-labeled glyphosate at 5.6 or 56 mg/kg showed that approximately 50% of the radioactivity was eliminated in the feces in the first 24 hours and >90% of the radioactivity was eliminated within 72 hours.[11] Urinary elimination was complete within 12 hours.

The toxicokinetics of glyphosate after single intravenous (i.v.)dose and oral doses was studied in rats.[85] For glyphosate, the elimination half-life ($T_{1/2}$) from plasma was about 14 hours after oral administration. The total plasma clearance was not influenced by dose concentration or route and

the results demonstrated considerable diffusion of glyphosate into tissues. After oral administration, glyphosate was partially and slowly absorbed with a $T_{max}$ of 5.16 hours with a bioavailability factor of 23%. Glyphosate was metabolized to aminomethyl phosphonic acid (AMPA), representing 6.5% of the parent glyphosate plasma concentrations; the maximum plasma AMPA concentration was reached after 2.4 hours. The half-life for excretion of AMPA was 15 hours after oral administration of glyphosate.

The placental transfer of glyphosate from mother to fetus was investigated using the ex vivo human placental perfusion method.[86] The transfer of glyphosate was restricted by the placental membrane barrier throughout perfusion, with approximately 15% of the glyphosate in maternal circulation crossing into the fetal circulation after 150 minutes. However, it should be noted that a steady state appears not to have been reached after 150 minutes, suggesting that glyphosate transfer was not complete during the study period. Cell permeability to glyphosate was also studied using BeWo (b30) cell monolayers.[87] Transport across the BeWo cells indicated that cell permeability and glyphosate transfer into the fetal compartment is slower and less complete than for caffeine and benzoic acid. The authors concluded that the in vitro results corresponded well with the ex vivo results.

Excretion in milk occurs at a low level in goats, with concentrations of <0.1 ppm observed in whole milk when goats were exposed to 120 ppm glyphosate in diet.[10]

Dermal absorption is also low. Dermal exposure to diluted Roundup in Rhesus monkeys resulted in 3.7–5.5 percent absorption after 12 hours of exposure.[88]

#### *3.3.1.B Acute Toxicity of Glyphosate*

Glyphosate has very low acute toxicity by the oral and dermal exposure routes, partly due to its limited absorption (see Section 3.3.1.A). In rats and mice, acute oral $LD_{50}$ values of glyphosate range from approximately 2,000 to 6,000 mg/kg. It is significantly more toxic by the intraperitoneal (ip) route. It is a moderate eye irritant in pure form, and substantially more irritating when formulated with POEA surfactant.

High doses of glyphosate cause hyperemia (increased blood flow), severe stress, accelerated breathing and occasional asphyxial convulsion.[11] The acute $LD_{50}$ of glyphosate for various species by different routes is given in Table 3-3.

Acute toxicity studies reviewed by WHO indicate that the $LD_{50}$ of glyphosate is mostly above 3,000 mg/kg, with a few studies on formulated glyphosate products with $LD_{50}$ values of ~2,000 mg/kg.[10]

**Table 3-3. Acute Toxicity of Glyphosate in Experimental Animals**

| Species/Mode | $LD_{50}$ (mg/kg) |
|---|---|
| Rat oral | 4,873 |
| Rat ip | 235 |
| Mouse oral | 1,568 |
| Mouse ip | 130 |
| Rabbit oral | 3,800 |
| Goat oral | 3,500 |
| Rat dermal | >2,000 |
| Rabbit dermal | >5,000 |

*Data source:* Adapted from Reference 11.

Glyphosate is not a strong dermal irritant. Irritation studies conducted by Monsanto using rabbits with intact or abraded skin showed glyphosate produced a relatively low irritant response.[89] Dermal testing of a formulated glyphosate at a concentration five times higher than the normal field application rate resulted in severe local skin reaction, reduced food consumption, body weight loss, mortality, and testicular effects.[90] Eye irritation of glyphosate technical and the formulated product Shackle® was tested in rabbits. Slight irritation was reported in some animals, and the irritation disappeared after a day or more.[91]

Acute toxicity studies (24 h) on the Norway rat (*Rattus norvegicus*) demonstrate the higher toxicity of Roundup compared to glyphosate, with a NOEL of 2,000 mg/kg-day for glyphosate and 200 mg/kg-day for Roundup for diarrhea, near-zero mortality, organ weight in relation to overall weight, and general injury.[92]

#### *3.3.1.C Reproductive and Developmental Toxicity of Glyphosate*

At low or intermediate doses in rats, there were few effects of glyphosate on mating, pregnancy and fertility indices. Effects noted include reduced fetal body weights at the highest doses tested in most studies, and reduction in liver to body weight ratios in second generation offspring in all treatment groups in multi-generation studies. Slightly reduced litter sizes were observed, although this result was not dose-dependent. Glyphosate affects sperm quality at moderate doses (38 mg/kg-day) in rabbits; a comparable study in rats was not available.

Table 3-4 below provides a summary of reproductive and developmental toxicity of glyphosate in tests with laboratory animals treated with glyphosate alone, without surfactants. There is great variability in the dose ranges tested in the different studies, from 3–30 mg/kg-day (rats) in the lowest-dose study to 300–3,500 mg/kg-day (rats) in the highest-dose study.

### Glyphosate and Salts

The human RfD is based on a NOAEL of 175 mg/kg-day from a developmental toxicity study in rabbits dosed from gestation days 6–27. While no statistically significant fetal developmental effects were observed compared to control groups, maternal effects included soft stools, diarrhea and nasal discharge at the middle and highest dose tested (HDT) and maternal mortality (62% death rate) at the HDT caused by pneumonia, respiratory disease, enteritis, gastroenteritis, or unknown mechanisms. In its most recent risk assessment,[7] EPA indicates that the observed

effects are likely a result of the bolus oral dose of glyphosate acid given to the rabbits, with similar effects observed in rat studies at higher dose levels. Because these effects are unlikely in animals eating a diet contaminated with glyphosate, a different study was used for the mammalian TRV.

The acute and chonic mammalian TRV is based on a parental/systemic and offspring NOAEL of 500 mg/kg-day from a 2-generation reproductive study in the rat in which glyphosate was administered in the diet instead of as a bolus dose. The LOAEL of 1,500 mg/kg-day is based on an endpoint of soft stools, decreased body weight gain, and food consumption. The reproductive NOAEL is 1,500 (HDT) mg/kg-day. In other studies, only very high doses (3,500 mg/kg-day, rats), cause statistically significant decreases in viable fetuses, mean fetal body weight, and maternal survival.

An increased incidence of unilateral renal tubular dilation in the male pups of the F3b generation was observed at 30 mg/kg-day in a 3-generation study with rats dosed at 10–30 mg/kg-day, but this result was not reproducible in a second study in which rats were dosed at much higher levels (150–2,200 mg/kg-day) for two generations. These two multi-generation studies may not be directly comparable, but the null result in the second study has been used by EPA to justify discounting the observed result in the first one.

In the US EPA's 1990 IRIS risk assessment, a chronic RfD for glyphosate of 0.1 mg/kg-day was derived from the NOEL of 10 mg/kg-day from the 3-generation study, based on increased incidence of unilateral renal tubular dilation. However, in the 1993 reregistration decision for glyphosate, US EPA selected a RfD of 2 mg/kg-day from a NOEL of 175 mg/kg-day based on maternal toxicity in the rabbit study. There is no indication of the reason for the change in the RfD in any of the publicly available US EPA documents.

### Formulated Products

Reproductive and developmental toxicity studies conducted with Roundup containing a POEA surfactant are not included in Table 3-4, but much higher developmental toxicity was observed with Roundup compared to glyphosate. In one study, 50% of the dams died between day seven and 14 of pregnancy at a dose of Roundup that was one-third the dose of pure glyphosate.[93] Skeletal alterations such as incomplete skull ossification and enlarged fontanel were also observed with Roundup, but not glyphosate, at dose levels that did not cause maternal toxicity. In a follow-up study, formulated glyphosate (with surfactants) was administered in drinking water to female rats during pregnancy and lactation at 50, 150 or 450 mg/kg.[94] Male and female offspring were followed into puberty and adulthood. No maternal toxicity was reported. In female offspring, a small but statistically significant delay in vaginal canal-opening at all dose levels was reported. In male offspring, decreased sperm number and production, increased abnormal sperm, and decreased serum testosterone levels were reported but these effects were not dose-dependent.

In a study evaluating the effects of Roundup (with surfactant) on testosterone levels, newly weaned male rats were administered glyphosate in the form of Roundup by oral gavage at dose levels of 0, 5, 50, or 250 mg/kg b.w. per day from post natal day 23 through day 53.[95] Roundup treatment delayed the progression of puberty in a dose-dependent manner with statistically

significant effects at 50 and 250 mg/kg. No change in body weight was reported at any dose. Dose-dependent reductions in serum testosterone levels were observed at all doses, with a statistically significant 30% reduction at the lowest dose and a 50% reduction at 250 mg/kg. Serum estradiol levels were unchanged. Statistically significant changes in seminiferous tubule epithelium height and luminal diameter were also observed at all doses, however the biological significance of these findings is unclear since sperm production and quality were not measured.

**Table 3-4: Reproductive and Developmental Toxicity of Glyphosate to Mammals**

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed Effects |
|---|---|---|---|---|
| CD rats[96] | 3 generations | 3, 10, 30 oral, in diet | 10 (NOEL) | No consistent, dose-related effect was seen in mating, fertility or pregnancy indices to indicate an adverse effect of treatment. For all treated groups, liver to body weight ratios of F2b parental females were significantly lower than controls for F2b females and liver to brain weight ratios were also reduced; however, no dose-response releationship observed and effect not observed in treated parents from previous generations. Increased incidence of unilateral renal tubular dilation in the male pups of the F3b generation at HDT, but this was not reproducible in a second study. |
| CD rats[97] | 2 (F0 treated for 11 weeks before mating) | 150, 720, 2,200 (oral, in diet) | 720 (NOEL) | F0 and F1 adults had reduced body weights (8 to 11 percent) at HDT. Mating, pregnancy, and fertility indices not affected by the treatment in both F0 and F1 animals. The average litter size of high-dose F0 dams was ~2 pups less than controls, and a smaller difference (approximately 1 pup/litter) noted after the first F1 mating, but not statistically significant. No treatment-related decrease in litter size was observed in the F2b generation |
| Rats[98] | Gestation | 0.5%, 1% glyphosate w/v in drinking water | NR | Significant decrease in food and water consumption and maternal body and liver weights at HDT. No differences in fetal body weights. Enzyme effects noted, but dose-response not always observed. |
| Rabbits[99] | 6 weeks | 0.01*$LD_{50}$, 0.1*$LD_{50}$, but $LD_{50}$ not stated. $LD_{50}$ from a different rabbit study was 3,800 mg/kg-day (see Table 3-3), which translates to doses of 38 and 380 mg/kg-day (oral, in gelatin capsules) | NA | Reduced body weight, ejaculate volume and sperm concentration and increased abnormal and dead sperm at both dose levels. Adverse effects continued into the recovery period. |
| Norway rat[8] | 2-generations | 500, 1,500 (10,000, 30,000 ppm in diet) | 500 (Parental, systemic and offspring NOAEL for mammalian TRV)<br><br>1,500 (Reproductive NOAEL) | Soft stools, decreased body weight gain and food consumption in parents and decreased body weight gain during lactation in pups. |

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed Effects |
|---|---|---|---|---|
| COBS CD rats[100] | GD 6–19 | 300, 1,000, 3,500 | 1,000 (NOAEL) | Statistically significant decrease in viable fetuses and mean fetal body weight at HDT. Reduced maternal body weight gain and early death at HDT. |
| Rabbits[101] | GD 6–27 | 75, 175, 350 | 175 (NOAEL for human RfD)<br><br>350 (LOAEL) | Increase in the incidence of soft stools and diarrhea in middle dose and HDT and nasal discharge at HDT. Statistically significant early maternal mortality at HDT (62%), caused by pneumonia, respiratory disease, enteritis, gastroenteritis, or unknown mechanisms. No biologically meaningful differences in mean number of viable fetuses, early or late resorptions, total implantations, corpora lutea, fetal body weights, fetal sex distribution, or number of fetuses or litters with malformations in any of the treatment groups compared to the controls. Slight decrease in mean fetal body weight of all treated groups, but not significant relative to historical controls. In its most recent risk assessment,7 EPA indicates that the observed effects are likely a result of the bolus oral dose given to the rabbits. |
| | | **Chronic RfD (OPP)** | **175/(10*10)[a] = 2** | **EPA OPP's human RfD, based on early maternal mortality, soft stools, diarrhea, nasal discharge in rabbits.** |
| | | **Chronic RfD (OPP)** | **500** | **EPA OPP's mammalian TRV, based on soft stools, and decreased body weight gain** |

NA = not available; NR = not reported; GD = gestation day; HDT = highest dose tested; M = male; F = female.
**Shaded** rows are the studies on which the RfD is based.
[a]Intraspecies uncertainty factor of 10 and interspecies uncertainty factor of 10.

### *3.3.1.D Endocrine Disruption*

A European Union survey of the scientific literature on endocrine effects of pesticides does not list glyphosate as a chemical of concern,[102] nor do other sources of information on endocrine disrupting effects.[103] However, glyphosate has been subjected to a number of *in vitro* assays for estrogenic activity in recent years. One of these studies showed cell proliferation effects not deemed to be estrogenic in nature, two studies showed no estrogen receptor binding, and four studies evaluating the effects of both glyphosate alone and Roundup formulations on aromatase activity showed reduced activity at glyphosate concentrations high enough to cause cell death (aromatase is an enzyme that converts estrogen to testosterone). There was no evidence of the very low-dose effects observed for known endocrine active compounds such as natural estrogens

or diethylstilbestrol (DES). No studies were found that explored the androgenic or thyroid effects of glyphosate, although one study found that high doses of glyphosate-based herbicides (on the order of a dose that would likely cause symptoms of acute poisoning) may affect the retinoic acid-mediated pathway that controls embryonic development. We describe these studies in more detail below.

It should be noted that the *in vitro* tests discussed below were conducted in isolated cell cultures. These kinds of tests provide information on the potential for adverse effects in the whole organism, although they do not account for the systemic processes that may serve to accentuate or mitigate an effect in the whole organism. As one author noted:

> *" . . . one of the nagging questions regarding in vitro environmental estrogen evaluation and detection of weak estrogenlike activity is whether these chemicals can have any clinically significant effects in vivo. Cultured cells deprived of background estrogens and nonestrogenic growth factors (CD-treated serum) may be sensitized to estrogenic stimuli. Moreover, the in vivo response to exogenous estrogenic stimuli in a hormonally balanced milieu may well be dampened."* [104]

Concentrations of the test substances used in *in vitro* tests of endocrine disruption are not directly comparable to doses in humans or experimental animals. *In vitro* studies should instead be compared to "positive controls" (known endocrine disruptors) to which the magnitude of any effects can be compared in the same assay as the test substance. In order to clarify systemic effects and dose/response in whole animals, it is necessary to complement the results of *in vitro* assays with *in vivo* bioassays. For glyphosate, no low-dose *in vivo* studies focused specifically on endocrine disruption effects tests were available. The extant studies of reproductive and developmental toxicity *in vivo* were conducted using high doses of glyphosate. We summarize the results of the *in vitro* studies below.

### Lin and Garry

Lin and Garry studied the potential for estrogenic activity of glyphosate on cell proliferation in MCF-7 human breast cancer cells.[104] Their work showed that cells treated with glyphosate and Roundup proliferated at 135 ± 3.5% and 126 ± 5.1% of the negative control, respectively. The range of glyphosate doses over which effects were observed was 0.228–2.28 mg/L, and the maximum effect was observed at a concentration of 2.28 mg/L ($10^{-4}$ M). For Roundup, the dose range was 1–10 mg/L, with maximum effect observed at 10 mg/L. The concentrations at which glyphosate and Roundup are active are 10,000 times higher than the concentration of DES that induced maximum proliferation in the same assay at a rate of 238 ± 29.5% of the negative control. For perspective, a concentration of 2.28 mg/L of glyphosate is approximately 3.3 times the glyphosate drinking water standard of 0.7 mg/L. This concentration is comparable to the doses tested in the standard toxicology tests; thus, the result cannot be described as a "low dose" effect. The authors concluded that glyphosate's effects were a result of non-estrogenic induction of cell proliferation.

### Petit and LeGoff

In a second study, Petit and LeGoff *et al.*[105] investigated estrogen receptor binding relative to the natural estrogen 17β-estradiol using two assays: 1) measurement of the estrogen-dependent

activity of β-galactosidase in a recombinant yeast system modified to express the rainbow trout estrogen receptor, and 2) measurement of vitellogenin gene induction in trout hepatocytes. Glyphosate showed no activity in either assay relative to the solvent control.

### Walsh and McCormick

In a third study by Walsh and McCormick *et al.*, the activity of glyphosate was assessed for its ability to alter steroid hormone biosynthesis in MA-10 mouse Leydig (testicular) tumor cells.[106] Glyphosate alone did not inhibit steroidogenesis (the process of formation of steroid hormone from precursor compounds) or total protein synthesis at any dose tested (0–0.100 mg/L). However, Roundup formulations reduced progesterone synthesis by 94%, with effects noted at concentrations as low as 0.010 mg/L. The authors indicate that this effect was possibly due to the effects of the surfactant on membrane function.

### Séralini *et al.*

The Séralini group has been studying effects of glyphosate and Roundup formulations for several years and has published a number of papers in which they describe the toxicity of glyphosate and Roundup products to human cell lines. The primary result of this work is one of the following:

- **Option #1:** Some of the adjuvants (surfactants or "inerts") in Roundup products have high toxicity and probable endocrine disrupting ability, while glyphosate alone is relatively inert.
  or
- **Option #2:** The toxicity of glyphosate is amplified by adjuvants, possibly by facilitating passage of glyphosate through cell membranes.

With the data currently in hand, it is not possible to distinguish between these two possibilities, although both are logically possible. Séralini's group suggests that Option 2 is the primary mechanism, noting that:[107]

> *In conclusion, according to these data and the literature, G-based herbicides present DNA damages and CMR [carcinogenic, mutagenic, toxic for reproduction] effects on human cells and **in vivo** (emphasis added). The direct G-action is most probably amplified by vesicles formed by adjuvants or detergent-like substances that allow cell penetration, stability, and probably change its bioavailability and thus metabolism (Benachour and Séralini, 2009). These detergents can also be present in rivers as polluting contaminants.*

This conclusion unnecessarily confuses the issue. By conflating "these data and the literature," "DNA damages and CMR effects" and "human cells and in vivo," the reader is left not knowing what, exactly, the study actually shows. A closer look at the paper indicates that no *in vivo* studies were conducted by the authors of the paper, certainly not on humans, as the sentence suggests. A clearer statement of the conclusions would be:

> *"Roundup 400 can cause DNA damage in human cell cultures at concentrations of 10 parts per million (ppm) of the product, equivalent to approximately 14 times the drinking water standard concentration of 0.7 ppm for glyphosate and an unknown concentration of the adjuvant. Prior work by other researchers indicates that some*

*Roundup formulations also exhibit in vivo effects on the avian reproductive system."*

The effects of glyphosate and Roundup on aromatase inhibition in human placental JEG3 cells were evaluated in a 2005 study by the Seralini research group.[108] This study did not include a positive control substance known to inhibit aromatase in the testing protocols, which is problematic for interpretation of results. It is also important to clarify that low-dose effects were not evaluated in this study; instead, the glyphosate concentrations tested in cell cultures were similar to concentrations applied as herbicides—between 0.05 and one percent solutions (500 to 10,000 mg/L). For comparison, in order to reach a serum concentration of 10,000 mg/L of glyphosate, a 70 kg adult male with a typical blood volume of five liters would have to drink at least 104 mL (about half a cup) of undiluted Aquamaster containing 480 g/L of glyphosate (this approximate calculation assumes that all of the ingested glyphosate would be circulating in the blood stream and not distributed to tissues, and is thus probably an underestimate of dose required to actually obtain a serum concentration of 10,000 mg/L). Thus, the doses tested in this study are not representative of any exposure that would occur from normal herbicidal use of glyphosate, but do have relevance to glyphosate poisonings caused by ingestion of large amounts of glyphosate-containing herbicides.

The raw data from this study indicate that glyphosate has no effect on JEG3 placental cell viability up to solution concentrations of 0.9% (9,000 mg/L) for a serum-containing medium. Above that concentration, aromatase activity in the cells decreased rapidly as cell death increased. Reduction in cell viability occurred at lower doses in a serum-free medium, between 4,000–8,000 mg/L. No reduction in aromatase activity relative to the negative control was observed at concentrations below 4,000 mg/L. From these data, the authors concluded that:

"*Our studies show that glyphosate acts as a disruptor of mammalian cytochrome P450 aromatase activity from concentrations 100 times lower than the recommended use in agriculture; this is noticeable on human placental cells after only 18 hr, and it can also affect aromatase gene expression. . . Roundup may be thus considered as a potential endocrine disruptor. Moreover, at higher doses still below the classical agricultural dilutions, its toxicity on placental cells could induce some reproduction problems."*

This concluding statement failed to mention that *"from concentrations 100 times lower than the recommended use in agriculture"* included concentrations of glyphosate up to one percent (10,000 mg/L). The other unstated, but obvious, conclusion from the data is that at high enough concentrations in the cell culture medium, glyphosate kills placental cells, thereby reducing aromatase activity through loss of viable cells that produce it. In other words, another explanation for the observed results is that the "disruption" in aromatase production was a result of cell death caused by the high concentrations of the chemicals to which the cells were exposed, and is unrelated to endocrine disruption. Later work by this same research group also focused on high-dose *in vitro* studies on human placental cells.[109] These high-dose studies are more relevant to the existing animal toxicology studies in the high dose regime and not at all relevant to the study of low-dose estrogenic effects.

More recent work by Seralini *et al.* suggests that the POEA surfactant in formulated Roundup products is much more toxic to placental cells than glyphosate and appears to have some estrogenic activity.[110] These studies were not definitive, with some tests indicating that POEA alone could cause adverse effects, and other tests indicating that POEA alone was not as toxic as POEA plus glyphosate. As a result, additional studies would be needed before it would be possible to conclude that the surfactant is enhancing the toxicity of glyphosate rather than the possibility that POEA is simply more toxic than glyphosate alone. In Séralini's prior work,[107] the toxicity of POEA alone was not evaluated, which is puzzling, considering the importance of this information for clarifying this hypothesis.

The Séralini group also studied the toxicity of different formulations of glyphosate and glyphosate-containing products to human hepatic cell lines.[111] This study was not related to endocrine disruption, but focused on narrowing the choices of mechanism by which Roundup® formulations cause toxicity to cells. The Roundup® formulations tested caused cell death at varying concentrations, depending on the formulation. The data indicate that certain formulations of Roundup cause a decrease in cell viability at concentrations between 0.005 and 0.01 percent of the formulated product. Glyphosate without surfactants does not start to affect cell viability until concentrations of approximately one percent are reached.

Because the concentration of glyphosate in the formulated products is different for the different products, the use of percent formulated product as a concentration measurement makes it difficult to compare glyphosate concentrations across the different experiments. Table 3-5 below highlights the confusion caused by use of these units.

**Table 3-5: Comparison of Glyphosate Concentrations Expressed as Percent of Formulated Product**

| Product | Concentration of glyphosate in pure product (g/L) | Concentration of glyphosate in a 0.005% solution (mg/L) | Concentration of glyphosate in a 1% solution (mg/L) |
|---|---|---|---|
| **Express** | 7.2 | 0.36 | 72 |
| **Bioforce** | 360 | 18 | 3,600 |
| **GT** | 400 | 20 | 4,000 |
| **GT+** | 450 | 22.5 | 4,500 |
| **Glyphosate** | NA (glyphosate is a solid) | 50 | 10,000 |

The work in this paper also showed that the toxicity of Roundup® formulations could be mitigated by the addition of Dig1, a new herbal drug comprised of plant extracts from *Taraxacum officinalis, Arctium lappa* and *Berberis vulgaris.*

Overall, the Séralini group's work indicates that high concentrations of Roundup® formulations with certain adjuvants are more toxic to cell cultures than glyphosate alone. These results certainly point to areas that may be fruitful for further study, but it is important to understand that the concentrations used in *in vitro* (cell culture) tests are not directly comparable to doses the humans or experimental animals may be exposed to, and in any case, the concentrations used are very high and not a realistic model of the exposure that people may encounter in any situation except a massive poisoning event. In order to clarify systemic effects and dose/response in whole animals, it is necessary to complement the results of *in vitro* assays with *in vivo* bioassays.

### Carrasco *et al*

Carrasco *et al* suggest that glyphosate-based-herbicides (GBH) and glyphosate disrupt embryonic development, and propose that GBH may be responsible for birth defects in humans in regions of high glyphosate use.[112] This conclusion is based on observation of developmental defects and increased retinoic acid[113] activity in amphibian and chicken embryos that were injected with GBH and glyphosate, as well as a study of birth defects in regions of high glyphosate use.

Carrasco *et al* conclude:

> *"The direct effect of glyphosate on early mechanisms of morphogenesis in vertebrate embryos opens concerns about the clinical findings from human offspring in populations exposed to GBH in agricultural fields."*

The experiments investigating the developmental toxicity of GBH were conducted in two ways: 1) culturing the embryos in solutions containing glyphosate or Roundup® (amphibian embryos); and 2) injecting the embryos with solutions of glyphosate or Roundup® (amphibian and chicken embryos).

For the experiments in which the embryos were cultured in solutions containing GBH, concentrations outside the cells were 430 umole/L (72.7 mg/L), and the calculated concentrations inside the cells were 8–12 umole/L (1.69 mg/L). For comparison, the USGS measured a maximum concentration of glyphosate in surface waters of 0.956 mg/L in an area of high glyphosate use (in the Midwest in an area where GMO crops are cultivated extensively).[114] Thus, the high doses to which the embryos were exposed are not representative of exposures likely to be experienced by humans who ingest or contact glyphosate-treated crops, or for amphibians living in areas of high glyphosate use, which makes these experiments not particularly useful for estimating the risks of developmental toxicity from likely exposures to GBH.

Monsanto published a critique of the paper, in which they highlight the substantial database of *in vivo* studies conducted for regulatory purposes that show no low-dose effects on fetal development.[115] They critique the dosing levels and exposure route as not being representative of any real-world exposures. They also question the power of the birth defects data used by Carrasco to suggest that birth defects are more common in areas of high glyphosate use by noting:

> *"The referenced epidemiology paper implied by the authors as justification for implicating glyphosate as a chemical of concern does not mention glyphosate or even distinguish between herbicide, insecticide, molluscicide, rodenticide, or fungicide potential exposures to pregnant women. This small epidemiological study, conducted in Paraguay, investigated associations between proximity or assumed exposure to pesticide use/storage and congenital malformations in neonates. The association between "living near treated fields" (distance and pesticide types unspecified) and congenital malformations was weak, with an odds ratio about six times lower than the reported association between pesticide storage in the home and congenital malformations. There is nothing unusual*

> *about the wide variety of birth defects reported in the Paraguay study and it provides no support for the authors' allegation that they "strikingly resemble the wide spectrum phenotypes resulting from a dysfunctional RA or Shh signaling pathway."*

We were not able to obtain the epidemiology paper and thus have not independently evaluated it.

Carrasco responded to the Monsanto piece, noting the inherent conflict of interest in registrants conducting toxicity testing of chemicals they stand to profit from and reiterating his conclusions.[116] He generally defended his work, although with more emphasis on the idea that these studies *may* provide evidence of a problem, rather than making a statement that GBH definitively cause birth defects. In particular, Carrasco reiterated that the work done in his laboratory demonstrates that high doses of GBH can affect the retinoic acid signaling pathways in embryos and defends the work as proof of principle of a molecular mechanism. The criticism that the doses used were not representative of possible exposures was not addressed, and remains problematic. The action of taking the result one step further to link to observed birth defects in high glyphosate use areas was not so well defended in this response and Carrasco presented multiple lines of evidence to support his hypothesis, none of which were definitive. Seeming to recognize this, Carrasco noted:

> *These data should be sufficient to raise the alert worldwide and lead to the commissioning of an independent study to provide an unbiased and dispassionate evaluation of the information rather than relying on studies commissioned by companies or requested by the U.S. Drug Enforcement Agency in support of their efforts to eradicate coca plantations.*

It is also worth noting that pesticide products marketed and used outside of the U.S. may have different formulations than those used inside the U.S., so it is difficult to use the birth defects data taken from a region of high pesticide use in Argentina to draw conclusions about exposure and hazard potential in the U.S.

### US EPA Endocrine Disruptor Screening Program

A comprehensive testing of the endocrine disrupting properties of glyphosate and other pesticide chemicals is currently in progress in the U.S. In 1996, Congress charged the US EPA with the task of screening pesticides for endocrine-disrupting potential.[117] The goal is to have a rapid assay that can quickly screen large numbers of chemicals with limited use of animal testing. To date, EPA has developed a number of screening assays and has validated most of the testing protocols.[118] The National Toxicology Program (NTP) is assisting EPA with developing method validation procedures for the *in vitro* estrogen receptor and androgen receptor binding and transcriptional activation assays.[119] The method validation procedures were published in 2002 and updated in 2006,[120] and will be used to evaluate the pesticides on EPA's list.

In June 2007, the EPA published a draft list of initial pesticides to be screened that included glyphosate,[121] as well as policies and procedures to be implemented in the Endocrine Disruptor Screening Program.[122] The finalized list of pesticides to be screened and the procedures for conducting the screening were published by EPA in April 2009,[123] and EPA sent out test orders

to manufacturers during the summer of 2009. Testing will take approximately two years to complete, and results will be reviewed by EPA's Scientific Advisory Panel before EPA decides how to utilize these results in its risk assessment process.

### Conclusion

The fact that no low-dose estrogenic effects were observed for glyphosate in all of the *in vitro* studies described above and that no endocrine effects have been noted in *in vivo* studies or in wildlife exposed to glyphosate alone, in spite of its widespread use, strongly suggests that glyphosate by itself is not an endocrine disruptor. Concerns remain about the toxicity of the surfactants used in these products. At high doses (substantially higher than any realistic exposure scenarios), formulated glyphosate-based-herbicides appear to impair embryonic development. Glyphosate is one of the first set of chemicals slated for testing of endocrine disrupting effects by U.S. EPA, and more information will be available when those tests are completed. Unfortunately, the issue of surfactant toxicity will not be resolved by the EPA testing.

#### *3.3.1.E Sub-Chronic Toxicity of Glyphosate*

Short-term exposure to glyphosate (a few months to a year), even at high doses, had no effects on the survival of test animals. The most common effect, observed at all dose levels, was salivary gland lesions. Observed effects at the higher doses tested include increased weights of liver, kidney, brain and heart; decreased thymus weight; decreased sperm density, changes in blood chemistry, and decreased pituitary weights (dogs only). See Table 3-6 for a summary of glyphosate toxicity tests.

A review of US EPA's Ecotox database for sub-chronic laboratory studies on Norway rats show NOELs of 300–560 mg/kg-day for changes in blood chemistry, enzyme levels, and cellular changes, as well as reduced weight gains in studies lasting 2–13 weeks).[9] Slight elevations in liver enzymes and liver tissue changes have been observed at doses of 56 and 560 mg/kg of Roundup (with POEA), including mononuclear cell infiltration, apoptosis of hepatocytes, focal necrosis, and congestion and swelling of hepatocytes.[124]

#### *3.3.1.F Chronic Toxicity and Carcinogenicity of Glyphosate*

There are a number of long-term (lifetime) dosing studies for glyphosate. Observed effects at the higher doses (greater than ~2,000 mg/kg) include weight loss, increased liver weights, and inflammation of the gastric mucosa. The cancer data are equivocal. Tumors were observed at various sites in some of the high-dose and intermediate-dose animals. However, results did not always follow a dose-response curve, and/or were not significant relative to historical control data. The weight of the evidence supports US EPA's classification of glyphosate as "E—Evidence of non-carcinogenicity for humans." The available studies are summarized in Table 3-7.

**Table 3-6: Sub-chronic Toxicity of Glyphosate to Mammals**

| Test animal | Study Duration (days) | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed Effects |
|---|---|---|---|---|
| CD-1 mice[125] (Monsanto) | 90 | 940, 1,890, 9,710 (M)<br>1,530, 2,730, 14,860 (F)<br>98.7% pure glyphosate in diet | 1,890 (NOEL) | Liver weights increased. At highest doses, growth retardation and increased organ weights of brain, heart, and kidney |
| CD-1 mice[6] (Monsanto) | 90 | 250, 500, 2,500 | 500 (NOEL) | Reduced body weight gains in high-dose mice (M and F) |
| Sprague-Dawley rats[126] (Monsanto) | 90 | 63, 317, 1,267 (M)<br>84, 404, 1,623 (F)<br>glyphosate in diet | 1,267 (NOEL) | No toxic effects observed. Hematology, blood chemistry, and organ weights not affected by the treatment. |
| F344N rats[127] (NTP) | 91 | 3,125, 6,250, 12,500, 25,000, 50,000 ppm in diet (M and F) | No NOEL identified | No effect on survival. Reduced weight gain (M at 25,000). Increased organ weights: liver (M at 3,125); kidney and testes (M at 25,000). Decrease in thymus weight (M at 50,000). Changes in blood counts (F at 3,125). Increased alkaline phosphatase (M at 6,250; F, 12,500) and alanine aminotransferase. Decreased sperm density (M at 25,000). Dose-dependent salivary gland lesions at all doses, M and F. |
| B6C3F1 mice[127] (NTP) | 91 | 3,125, 6,250, 12,500, 25,000, 50,000 ppm in diet (M and F) | 507 mg/kg (NOEL) (equivalent to 3,125 ppm in diet) | No effect on survival. Reduced weight gain (M and F at ≥25,000). Increased organ weights, but not dose-dependent. No effect on sperm motility. Salivary gland lesions, but not at lowest dose. |
| Beagle dogs[128] (Monsanto) | 365 | 20, 100, 500 orally by capsule | 500 (NOAEL) | No observed adverse effects in clinical signs, body weight, eyes, blood chemistry, gross pathology and histopathology. Changes in pituitary weights (M, ≥500), but significance is not clear since no histological changes. |
| Rabbits[129] | 21 | 100, 1,000, 5,000 dermally 6 h/d, 5 d/wk | No NOEL identified | No effect on survival and growth. NO evidence of systemic toxicity. Slight erythema and edma in both intact and abraded skin observed at HDT. |
| Cows[130] | 7 | 400, 500, 630, 790 by nasogastric tube | 400 (NOAEL) | At HDT, 1/3 animals died from pneumonia caused by aspiration. Decreased feed intake (≥630); diarrhea (≥500). |
| | | **Sub-chronic RfD** | **NA** | **US EPA sub-chronic RfD not defined for glyphosate** |

HDT = highest dose tested; NTP = National Toxicology Program; M = male; F = female; RfD = reference dose.

### Table 3-7: Chronic Toxicity of Glyphosate to Mammals—Cancer

| Test animal | Study Duration (months) | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed Effects |
|---|---|---|---|---|
| Sprague-Dawley rats[131] (Monsanto) | 24 | 3.1, 10.3, 31.5 (M) 3.4, 11.2, 34 (F) oral, in diet | 31.5 (NOEL) | Survival, hematology, blood chemistry, urinalysis, and organ weights not affected by the treatment. Increase in c-cell thyroid carcinoma in high-dose group, but no dose-response. Significant increase in testicular tumors in high dose males, but age differences could explain this result. This result was not duplicated in a second study. |
| Sprague-Dawley rats[132] (Monsanto) | 24 | 100, 410, 1,060 oral in diet | 410 (NOEL) | No change in survival, appearance, or blood chemistry noted in treated animals. Reduction in body weight gain in high-dose F rats. Increased liver weight in high-dose M rats. Degeneration of lens capsule fibers in eye. Inflammation of gastric mucosa in medium- and high-dose F rats and M rats (but not statistically sigfnificant). Increase in pancreatic islet cell adenomas, but no carcinomas were observed. Increase in adrenal cortical carcinoma at HDT (F). |
| CD-1 mice[133] | 24 | 157, 814, 4,841 (M) 190, 955, 5,874 (F) oral in diet | 814 (NOEL) | Decrease in body weight and adverse liver and kidney effects at HDT. Bronchiolar-alveolar lung tumors, hepatic tumors, and tumors of the lymphoreticular system were observed. No clear dose-response relationships were noted and the tumor incidence was not statistically significant compared to historical controls. |
| | | **Chronic RfD** | **NA** | **US EPA chronic RfD is defined by a developmental toxicity study. See Table 3-4.** |

HDT = highest dose tested; M = male; F = female.

### *3.3.1.G Genetic Toxicity and Oxidative Stress*

Glyphosate has also been tested in *in vivo* and *in vitro* genetic test systems and was found to be mostly negative for gene mutation, chromosomal aberration and DNA damage. The final assessment of US EPA and CA OEHHA is that the weight-of -evidence suggests that glyphosate is neither mutagenic (i.e., causing a structural or functional change in genetic coding) nor clastogenic (i.e., causing or inducing disruption or breakages of chromosomes or other genetic material). However, *in vitro* (animal and human cells) and *in vivo* (animal) data published since these reviews provide some evidence that formulated glyphosate products containing surfactants, or to a lesser degree glyphosate alone, might have clastogenic activity at high doses. These effects may be due to the oxidative stress caused by high concentrations of glyphosate.

The genotoxic and oxidative potential of glyphosate were evaluated using both a standard and modified comet assay on human lymphocytes at concentrations ranging from 0 to 580 μg/mL.[134] The results using the standard comet assay indicate a statistically significant increase in DNA damage (tail length increase) at 580 mg/L without metabolic activation (-S9) whereas a clear but small dose-dependent increase from 3.5 to 580 mg/L with metabolic (+S9) activation. The results with the modified comet assay are less clear. The authors stated that "Glyphosate was tested in the final concentrations of 0.5, 2.91, 3.5, 92.8, and 580 μg/mL. Concentrations were chosen to correspond to values of acceptable daily intake (Annex I, EU directive 91/414/EEC), residential exposure level [US EPA], occupational exposure level (OEL) [US EPA], 1/100 $LD_{50}$ (Annex I, EU directive 91/414/EEC) and 1/16 of oral $LD_{50}$ in rats (Annex I, EU directive 91/414/EEC), respectively."

Chromosome aberrations, sister chromatid exchange (SCE), and mitotic index were studied in peripheral lymphocytes from three healthy donors exposed *in vitro* to different concentrations of glyphosate (atrazine and vinclozolin were also evaluated).[135] Glyphosate produced a dose-related increase in the percent of aberrant cells and an increase of SCE per cell, but did not affect the mitotic index.

In a study of the induction of SCE in human lymphocytes *in vitro*, much higher concentrations of glyphosate were required to produce an effect than the other two pesticides studied (the fungicides captan and fenaminosulf).[136]

DNA microarray analysis[137] was used to determine a formulated glyphosate product's capacity to alter steroid receptor gene expression in the presence or absence of 17β-estradiol (E2). DNA microarray analysis indicated that a large number of genes, 680 out of 1550, are potentially dysregulated in cultured mammalian cells (MCF-7) following the addition of 0.015, 0.0015, 0.00015 or 0.000015 percent solutions of a formulated glyphosate product (with surfactant) for homeowner use. A subset of genes was further analyzed and it was confirmed that 3 of 29 genes (EGR1, CXCL12 and HIF1) met the definition of dysregulation. Estrogen increased the effects of the formulation mixture on the expression of these three genes.[138]

Human peripheral blood mononuclear cells were exposed to different concentrations of Roundup and technical grade glyphosate for 24, 48, 72, and 96 hours. The Roundup formulation was more cytotoxic (cell damaging) with an $LC_{50}$ (50% lethal concentration) of 56.4 μg/mL at 24 hours, compared to 1,640 μg/mL for technical grade glyphosate.[139]

A small (2-fold) but statistically significant increase in chromosome aberrations was observed for aminomethyl phosphoric acid (AMPA), the major environmental breakdown product of glyphosate, in human lymphocytes after 48 hours of incubation.[140] In the same study, the comet assay was used to evaluate the in vitro genotoxicity of 2.5–7.5 mM (278–832 mg/L) AMPA after four hours of incubation in Hep-2 cells. A dose-dependent, statistically significant increase in tail moment, tail length, and percent DNA in tail was reported, indicating DNA damage at a greater than the positive control, mitomycin C. This study utilized high doses of AMPA and is only relevant to acute poisoning scenarios.

Several studies in which high doses of glyphosate (>1.4 mg/L) were used show positive results for sister chromatid exchange (SCE) in human lymphocytes,[141] a result supported by two other in vitro studies that also replicated the findings in bovine lymphocytes above 2.9 mg/L.[142] In a third study, SCEs but not chromosome aberrations were induced by a glyphosate formulation at 56 to 1,120 mmol/L (189,392 mg/L) in bovine lymphocytes without metabolic activation.[143] [These outcomes may have been a result of oxidative stress at the high concentrations tested.

One study in which glyphosate was administered to male mice by intraperitoneal (i.p.) injection (at 2 x 150 mg/kg) resulted in increased micronuclei (MN) in bone marrow cells;[141] however, this dose was very high, more than the i.p. $LD_{50}$ for mice of 130 mg/kg. Grisolia et al. reported no increases in MN in polychromatic and normochromatic erythrocytes in mice following 50, 100, or 200 mg/kg Roundup administered by i.p. injection. The maximum tolerated dose of Roundup was reported to be 200 mg/kg.[144]

Genotoxic effects of the herbicide glyphosate were analyzed by measuring chromosomal aberrations (CAs) and MN in mouse bone marrow cells. A single dose of glyphosate formulation (Roundup) was administered by i.p. injection to the animals at a concentration of 25 and 50 mg/kg. Roundup statistically significantly increased CAs and MN induction at both concentrations. The cytotoxic effects of glyphosate were also evident, as observed by significant decrease in mitotic index (MI).[145]

In contrast, negative results were reported in studies where the animals were dosed orally instead.[146] The registrant Monsanto Company confirmed and then investigated the mode of action for DNA adduct formation and concomitant damage in mouse liver and kidney following i.p. administration of glyphosate or glyphosate herbicide formulations as reported by independent researchers. The authors concluded that the observed effects were specific to route of administration and suggest that i.p. injection of glyphosate formulations may induce secondary effects mediated by local toxicity rather than genotoxicity.[147]

Potential *in vivo* genotoxicity of the glyphosate metabolite AMPA was evaluated through the micronucleus test in mice. At 200–400 mg/kg (total dose over two days and two i.p. injections), a statistically significant 2.7-fold increase in micronucleated ethrocytes was reported. By comparison, the positive control cyclophosphamide induced a 5-fold increase.[148]

Malatesta et al. treated hepatoma tissue culture (HTC) cells with 1-10 mM Roundup and analyzed cellular features by flow cytometry, fluorescence and electron microscopy. Cell

mortality and cell division were not affected. However, an increase in the number and size of cytoplasmic vacuoles and lysozomes was observed and as were changes in the integrity of mitochondrial membranes as measured by a large drop in the mitochondrial membrane potential.[149]According to the authors, these results are indicative of early signs of cell death in liver tissue at potentially biologically relevant doses.

Oxidative damage to human skin cells from glyphosate and a Roundup formulation was studied in the keratinocyte (epidermal) cell line HaCaT by measuring $IC_{50}$, which was defined as the concentration of a toxicant resulting in 50% cell death, and the kinetics of cell death.[150] Glutathione levels and catalase, peroxidase, and superoxide dismutase activities were measured to assess the cell's natural protective mechanisms against oxidative stress induced by the herbicide. Concentrations of the chemicals/mixtures studied ranged from 10–25 mM (1,691–4,227 mg/L). Overall, Roundup appears to be slightly more toxic to cultured epidermal cells than glyphosate alone. Simultaneous addition of the antioxidants Vitamin C or E were found to slow the rate of cell death caused by glyphosate alone or Roundup and attenuate the oxidative damage induced by Roundup.

In a follow-up study, the same authors studied the dynamic events of the loss of HaCaT cell integrity appearing after the addition of high levels (10–70 mM or 1,690–11,830 mg/L) of non formulated glyphosate after 0.5, 4, 18, and 24 hours.[151] Glyphosate at these concentrations is able to disrupt HaCaT cells and to induce intracellular oxidative cascade. The membrane damage, disorganized cytoskeleton, condensed chromatin, and overproduction of oxidative reactive species lead the authors to conclude that glyphosate acts in induction of apoptotic process. This study only has relevance to acute poisoning events where exposure to very high doses of glyphosate occurs.

Genotoxic effects of oxidative stress induced by a combination of $H_2O_2$ (hydrogen peroxide) and glyphosate was determined in human fibroblasts.[152] Damage to DNA was found in the presence of low amounts of glyphosate and mild oxidative stress, but glyphosate was not genotoxic when applied separately.

#### *3.3.1.H Neurotoxicity*

Glyphosate has been tested for neurotoxicity in rats and hens and found to be negative for indications of neurotoxicity. Acute exposures of rats to relatively low doses of glyphosate (one dose of 50, 100 or 200 mg a.e./kg) showed no effects on landing foot splay, sensory perception, muscle strength, or locomotor activity and no abnormal histologic changes in the central or peripheral nervous system tissue over a two-week period.[153] Six hours after dosing, the animals exhibited decreased activity, subdued behavior, and hypothermia, but this was not attributed to glyphosate's effects on the nervous system.

A subchronic study in which rats were dosed with glyphosate in their diets at concentrations of 2,000, 8,000, or 20,000 ppm for 13 weeks showed no neurologic effects, as assessed by changes in locomotor activity, brain weight or dimensions, or damage to nerve tissue (peripheral or central).[154] Effects were noted on growth and food utilization, but again this was not attributed to glyphosate's effects on the nervous system.

Evaluation of delayed neurotoxicity using the standard hen assay[155] showed a slight decrease in brain acetylcholinesterase (AChE) activity after a single gavage dose of glyphosate at 2,000 mg/kg. Delayed locomotor ataxia and neuropathology were not observed.[156]

A dog study conducted by Monsanto is described in the USFS risk assessment.[5]

> *"Williams et al. (2000) also describe a study in which neurological examinations were conducted on dogs that received a single oral dose of 59 or 366 mg/kg of Roundup and the information is attributed to an unpublished study by Monsanto which is cited as Naylor (1988). This study was not identified in a search of the US EPA/CBI files and has not been reviewed in preparation of this risk assessment. According to Williams et al. (2000):*
>
> *'A detailed examination consisting of 12 different measurements of spinal, postural, supporting, and consensual reflexes was performed before treatment, during the postadministration observation period, and again on the following day. Reflexes appeared normal, and there were no clinical signs indicative of neuromuscular abnormalities.' "*

No signs of neurotoxicity were noted in the other sub-chronic studies (see Section 3.3.1.E) where morphological examinations were conducted of the brain (including basal ganglia, a site of injury in Parkinsonism). However, it is unclear from the report whether or not spinal cord and sciatic nerve were examined.[127] There is some speculation that the histological changes observed in salivary glands in both rats and mice may have been caused via an adrenergic mechanism involving the effect of adrenaline on the nervous system. This hypothesis is based on evidence that the histological changes were less severe in animals treated with drugs that are β-adrenergic neurotransmitter antagonists. Others disagree, since other β-adrenergic effects (e.g., on heart rate and blood pressure) have not been observed when glyphosate was administered intravenously to dogs or rabbits.[157] This debate remains to be settled.

A study evaluating the effect of glyphosate on taste response in gerbils demonstrated that glyphosate decreased taste receptor response.[158] This observation could be explained in one of several ways, including the possibility of a direct neurotoxic effect, biochemical alteration in the epithelial cells on the tongue, or by chemical injury. It is impossible to say definitively whether or not the observed decrease in taste was due to a neurologic effect.

Biochemical mechanisms of oxidative stress on the nervous system caused by analytical grade glyphosate alone and in combination with dimethoate and zineb were investigated in mitochondrial extracts from rat brain tissue.[159] Rats were dosed by i.p. injection with 10 mg glyphosate/kg body weight in PEG-400 and/or 15mg zineb/kg and/or 15mg dimethoate/kg in PEG-400. All the animals were dosed three times a week for five weeks. The authors stated that the doses used were consistent with those reported in previous works from other laboratories. No changes in behavior, water consumption, body weight or rate of body weight gain were observed in the study animals. Although glyphosate alone reduced the integrity of the inner mitochondrial membrane in the mid-brain and cerebral cortex by over 30% and 40% respectively, these effects were not statistically significant. However, membrane markers of intracellular oxidative stress

(cardiolipin reduction and proteolitic enzyme activation) and were altered with statistical significance by glyphosate alone. Oxidative stress in brain tissue mitochondria were more clearly demonstrated in mixtures of glyphosate, dimethoate, and zineb. The intraperitoneal route of exposure is not relevant to exposures to glyphosate from the Mount Sutro vegetation management project.

#### *3.3.1.I Immunotoxicity*

The powerful protective immune system is highly complex and interacts with all other body systems. The only way to determine potential immunotoxic effects of gyphosate is to directly study its effects on the immune system, including lymphoid tissue (lymphoid nodes, thymus), bone marrow, lymphocytes (B-cells and T-cells), antibodies, immunoglobulins, among other components. *In vitro* studies show little effect, except at very high doses where cytotoxic and genotoxic effects were observed.

Glyphosate has been tested specifically for effects on the immune system in both humans and experimental mammals. There is no evidence of an immune response in mammals caused by glyphosate, in either *in vitro* tests with human or sheep cells, or in human dermal exposures, where glyphosate was not found to cause sensitization. The details of these studies may be found in the USFS risk assessment.[5]

An investigation of the effects of glyphosate on cytokine production by human peripheral blood mononuclear cells, found only a slight inhibitory effect at the highest concentration (1,000 μM). Production of other cytokines important for the proper functioning of the immune system such as TNF-alpha and IL-1 beta were not affected. The author concluded that glyphosate "might be a pesticide with only a little damage to the immune system."[160]

Normal human cells (GM38) and human fibrosarcoma (HT1080) cells were exposed *in vitro* to differing concentrations of glyphosate.[161] Cytotoxic and genotoxic effects were found in the normal cells at 4.0-6.5 mM (676–1,099 mg/L). In the fibrosarcoma cells, cytotoxic and genotoxic effects were found at 4.75 -5.75 mM (803–972 mg/L). This study utilized high doses of glyphosate and is only relevant to acute poisoning scenarios.

#### *3.3.1.J Effects on Mammalian Wildlife*

US EPA's Ecotox database contains approximately 200 results of field studies on the effects of glyphosate on wild mammals, including mule deer, Norway rats, deer mice, several species of voles and shrews, and chipmunks.[9] A variety of toxicity endpoints were evaluated, primarily changes in species abundance. Survival, reproductive ability, weight loss and general injury were also evaluated. A reduction of populations of small mammals was noted in some field studies, but not others. Some of the observed effects are likely due to the secondary, indirect effects of habitat and food loss, not to the toxicity of glyphosate.

The effects of glyphosate treatment on the feeding preferences and daily food consumption of black-tail deer were evaluated.[162] Deer did not avoid eating browse of alder *(Alnus rubra)* and alfalfa *(Medicago sativa)* that was treated with glyphosate at a rate of 2.2 kg/ha. Sometimes the treated alder browse was even preferred. Effects on deer health were not reported.

A number of studies have been conducted on the effects of glyphosate applications on population, reproductive capacity, and survival of small forest rodents. These animals may come into contact with treated vegetation, eat contaminated food and drink contaminated water from application sites. Indeed, low-level residues of glyphosate were detected in small mammals for a short time after treatment.[163] A Monsanto-funded study of the populations of deer mice (*Peromyscus maniculatus*) and Oregon voles (*Microtus oregoni*) between a control and treated clear-cut area in Oregon over five years had mixed results, with treatment populations, weight and reproductive success exceeding those of control populations in some years, but not in others.[164] Overall, the authors concluded that a single Roundup treatment at 2.2 kg a.i./ha had no significant effects on survival and body mass of the two species.

Insectivorous shrews *(Blarina brivicauda, Sorex cinereus and Sorex hoyi)* and herbivorous voles were less abundant due to a treatment with Roundup at a rate of 1.3 kg a.e./ha.[165] This significant reduction of the number of shrews continued for three years after application, whereas the population of voles recovered. No effects on the populations of the omnivorous deer mice *(Peromyscus maniculatus)* were observed.

In a clear-cut area treated with Roundup at a rate of 1.1 kg a.i./ha, the population density of Southern Redbacked voles *(Clethrionomys gapperi)* was reduced by about 80% in a one-year experiment.[166] In another clear-cut, no adverse effects on deer mice populations were evident after treatment with Roundup at a rate of 1.6 kg a.e./ha.[167]

In contrast, a significant reduction in the population density of deer mice was observed in a treated clear-cut approximately 11 months after treatment with Roundup at 1.2 kg a.e./ha.[168] However, no adverse effects on fertility or fecundity were indicated. The authors speculate that the effect on abundance was due to habitat change with respect to food and cover. At lower application rates of Roundup (0.6 kg a.e./ha), deer mice were not affected.[169]

#### *3.3.1.K Levels of Concern for Mammals*

For the Mount Sutro risk assessment, we used the US EPA acute and chronic TRV of 500 mg/kg-day, based on a NOAEL in a 2-generation toxicity study in rats where soft stools, decreased body weight gain and food consumption in parents and decreased body weight gain during lactation in pups was observed at the next highest dose of 1,500 mg/kg-day. No adjustment of this value was performed to make it more protective because it was a NOAEL measured in a mammalian species. The USFS used the same TRV.

#### *3.3.1.L Data Gaps*

Glyphosate is one of the most well-studied herbicides on the market today, and the data set on its toxicity—comprised of many studies by Monsanto and a number of peer-reviewed literature studies—is fairly complete. Nevertheless, the toxicity of glyphosate when used in conjunction with different surfactants (besides POEA), as well as with other pesticides remains largely unexplored. Some aquatic toxicity data exist for glyphosate with non-POEA surfactants; these data show toxicity closer to that of glyphosate alone (see Section 3.3.3).

The available toxicity studies on AMPA, the primary degradation product of glyphosate, indicate that it is less toxic than glyphosate. No information is available on AMPA's carcinogenicity,

reproductive and developmental toxicity, neurotoxicity, immunotoxicity or endocrine disrupting ability. Available studies on AMPA and genetic toxicity indicate a potential for inducing genotoxic effects in vitro and in vivo, but only at very high doses.

### 3.3.2 Other Terrestrial Organisms

Glyphosate is considered to be not acutely toxic to birds, honeybees and soil microorganisms. Most studies with spiders and other insects suggest that glyphosate is only slightly toxic. Reproductive toxicity in birds has been observed at low doses of Roundup, but not for glyphosate alone. Glyphosate does not appear to do any long-term damage to soil fertility and microorganism communities, but may temporarily increase or decrease populations of certain fungi. There are conflicting studies concerning the toxicity of glyphosate to earthworms. The TRVs for terrestrial organisms are summarized in Table 3-8.

#### *3.3.2.A Birds*

Based on the available Monsanto studies submitted to US EPA and approximately a dozen studies in the avian toxicity literature, glyphosate is deemed to be not acutely toxic to slightly acutely toxic to birds. Although the EPA does not consider glyphosate to cause reproductive toxicity in birds, there is some evidence that Roundup formulations affect reproductive outcomes.

The acute toxicity of glyphosate to the standard avian test species (mallard ducks and bobwhite quail) is generally low. The Terretox database[9] (see Tables D-2 and D-3) and RED 1993[6] show $LD_{50}$ values >2,000 mg/kg of technical grade glyphosate for studies lasting eight days or less (see Section 2.3.4 for toxicity reference tables). An increase in the exposure time to three weeks results in a lowered tolerance for glyphosate exposure, with $LD_{50}$ values dropping to 950 mg/kg. For endpoints expressed as glyphosate concentrations in food, the Terretox database reports $LC_{50}$ values >4,650 mg chemical per kg food for all study species exposed to glyphosate for eight days. Since the EPA RED was published, more recent studies have shown even higher $LC_{50}$ values of 5,620 mg/kg (five day exposure).[170] This Monsanto study is not publicly available. The USFS reports that this acute toxicity study was actually a NOEC because no mortality was observed.

Most recently, US EPA conducted an endangered species Effects Determination for glyphosate as it may affect the California red-legged frog.[8] In this assessment, they utilized birds as a surrogate for terrestrial-phase amphibians and thus considered avian endpoints. Because the acute oral studies showed no mortalities at the highest doses tested, US EPA used values for chronic exposure in their acute risk assessment. For glyphosate alone (no surfactants), a NOAEC of 5,000 ppm (concentration in food) was converted to a NOAEL in mg/kg body weight using the USFS assumption of an acute food consumption rate of 0.3 kg food/kg body weight for quail, the acute NOAEL was calculated to be 1,500 mg a.e./kg bw.

For longer-term exposures, US EPA and USFS used a reproductive NOAEC of 830 ppm in bobwhite quail, which was converted to a NOAEL of 58 mg a.e./kg bw, assuming a chronic food consumption rate of 0.07 kg food/kg body weight. The precise reproductive effects were not described in the US EPA assessment. Two other studies[171a,b] report no reproductive effects of

glyphosate to bobwhite quail and mallard ducks at concentrations in food of up to 1,000 mg/kg of technical glyphosate (equivalent to a dose of approximately 100 mg/kg body weight).

In contrast, a different study using Roundup (presumably with the POEA surfactant) reported statistically significant reduced testosterone production and changes in testicular ducts in mallards exposed to a dose of 3.7 mg a.e./kg body weight.[172] This study also reports reduced weight of male sexual organs; however, this result was not statistically significant. The use of a different chemical formulation, as well as the more refined reproductive metric (concentration of testosterone) helps explain the difference in endpoint doses between the two studies.

Zebra finches experienced pronounced weight loss after dietary exposures of 5,000 ppm glyphosate.[173] After 3 to 7 days of eating glyphosate-containing food, birds consumed less food and lost an even larger fraction of their original body weight. This is consistent with observations in experimental mammals suggesting that glyphosate may inhibit oxidative phosphorylation and consequently reduce food conversion efficiency.

As reported in the USFS glyphosate risk assessment report, glyphosate does not cause teratogenic activity in birds,[174a–b] nor neurotoxicity in hens.[175]

**Levels of concern for birds:** For the Mount Sutro risk assessment, we used the US EPA avian acute TRV of 1,500 mg/kg-day and a chronic NOAEL of 58 mg/kg for products containing glyphosate with no surfactants or with low-toxicity surfactants. These values are from the five-day dietary NOAEC of 5,000 ppm reported for mallards and bobwhite quail and the 830 ppm reproductive NOAEC for mallards and bobwhite quail.[6] Food intake is typically assumed to be 0.3 kg food/kg of body weight for acute endpoints and 0.07 kg food /kg of body weight for chronic endpoints.

#### *3.3.2.B Terrestrial Invertebrates*

Although EPA only requires toxicity tests on honeybees as part of chemical registration data, numerous glyphosate toxicity studies have been done on other insects. Based on the EPA RED and the Terretox database, glyphosate does not appear to be acutely toxic to honeybees. It is slightly to moderately toxic to other insects, particularly spiders. There are conflicting studies concerning the toxicity of glyphosate to earthworms.

US EPA's Terretox database[9] and the US EPA glyphosate RED 1993[6] both report a 48-hour oral and contact $LD_{50}$ for bees at doses >100 µg/bee for both Roundup and technical grade glyphosate, a rating of not acutely toxic (see Section 2.3.4 for toxicity ratings). One study reports a 48-hour oral $LD_{50}$ greater than 100 µg/bee and a NOEL of 50 µg/bee.[176] Since all reports suggest that the $LD_{50}$ is not lower than 100 µg/bee, it is worth noting that references within the USFS risk assessment suggest that the $LD_{50}$ may in fact be much higher. A second study reported 5% mortality for an orally administered dose of 100 µg/bee.[177] This dose was classified as a NOEL because mortality was not significantly different from that in the matched solvent control. The Terretox data suggest that $LD_{50}$ values decrease as study time increases (see Table D-5). For a 96-hour study, the $LD_{50}$ for honeybees is 62 µg/bee, slightly lower than the $LD_{50}$ for the 48-hour exposure period.

Originally tested as a potential insecticide for spider mites, glyphosate has been shown to be practically nontoxic to *Tetranychus urticae*, a pest species on apple trees[178] and *Typhlodromus pyri*, an important predator of spider mites.[179] Direct foliar spray of glyphosate IPA at 0.44 to 3.51 mg ae per kidney bean leaf (assuming a leaf is 25 $cm^2$, this corresponds to a application rate of 7-56 kg/ha) had no effect on spider mites based on mortality in eggs, larvae, nymphs or adults.[178] An unpublished Monsanto study reports 100% mortality in spider mites in applications of 10 L/ha RoundUp ULTRA (or 3.6 kg a.e./ha) to glass slides.[180] The authors believe that mortality was enhanced due to the "sticky layer" that formed upon application, which may have rendered the insects immobile. The importance of this study in real-world applications is unclear, since insects in natural settings are not usually on surfaces similar to glass slides.

A series of laboratory and field studies[181a-c] on the effects of glyphosate on the spider *Lepthyphantes tenuis* found decreased populations with application rates of 0.36, 0.72, and 1.44 kg a.e./ha. However, mortality was attributed to secondary effects from changes in the vegetation.[181c] In the laboratory, the authors observed 6-12% mortality (statistical significance was not discussed) after three days in *Lepthyphantes tenuis* at the same application rates.[181b]No substantial diversity effects were observed in spider populations at field application rates of 0.09 or 0.18 kg a.e./ha.[181a] However, abundances of all spiders were decreased and weaver spiders (as compared to wandering spiders) were more affected.

Data on other arthropods are less detailed. Leaf litter exposed to application rates of 2.1 kg/ha glyphosate did not report statistically significant toxicity effects in *Philoscia muscorum*.[182] Rove beetles sprayed with 1% Roundup (3.6 g/L) at 6 µL/$cm^2$ experienced no measurable mortality or changes in egg-laying.[183] A series of studies evaluating herbicide effects on butterfly populations compared the effects of herbicide use to mechanical removal in rights-of-way maintenance and noted no significant population differences.[184]

The Terretox database reports mainly NOELs and LOELs for a variety of beetles, spiders, hemiptera, diptera, lepidoptera and a few unspecified insects (see Tables D-6 and D-7). The median NOEL for abundance decreases using Roundup is 0.62 kg/ha. The median NOEL for glyphosate is 1.2 kg/ha in ground beetles. The median LOEL for abundance for both glyphosate and Roundup is roughly 0.75 kg/ha. The maximum reported NOEL for any effect is 1.5 kg/ha for application of Vision to ground beetles, a factor of five lower than the maximum application rate on the Aquamaster label.

Three studies report the potential effects of glyphosate on earthworms. In a laboratory study, effects on earthworm cultures treated at levels equivalent to application rates of 0.0007 to 0.0028 kg glyphosate/ha included decreased growth rates and caused early mortality.[185] Although this study would suggest that glyphosate is very toxic to earthworms, the USFS notes that the study did not mimic field conditions and is therefore of limited relevance. In another study designed to mimic agricultural use,[186] no effects on earthworms were noted. However, reference 186 does not report exposures in either kg/ha or ppm soil and thus is not particularly useful for this risk assessment. The soil $LC_{50}$ for glyphosate to *Aporrectodea caliginosa*, a worm common in Libya, has been reported to be 246–177 mg glyphosate/kg soil dry weight over exposure periods of 8–37 days.[187]

One study is available on the toxicity of glyphosate to *Helix aspersa*, the brown garden snail. Diets containing 4,994 ppm glyphosate resulted in no mortality over a 14-day exposure period.[188] Assuming a 30% food consumption factor for this species, this corresponds to a dose of about 1,500 mg/kg (4,994 ppm × 0.3 mg/kg bw ppm = 1,498 mg/kg bw).

**Levels of concern for bees:** For the Mount Sutro risk assessment, we used the US EPA and USFS NOEL of 100 µg/bee (860 mg/kg using the average weight of 0.000116 kg/bee) as the TRV for honeybees in their risk analysis.

#### *3.3.2.C Terrestrial Plants*

To be an effective herbicide, glyphosate must be toxic to plants, and any off-target movement of herbicide spray will likely damage non-target vegetation. Table 3-8 on page 3-61 provides a summary of glyphosate toxicity to non-target vegetation. As a broad spectrum herbicide, the toxicity pathway for glyphosate is well understood.[189] Glyphosate kills plants by restricting the shikimic pathway, the pathway that allows plants to synthesize phenolic compounds and aromatic amino acids (phenylalanine, tryptophan, and tyrosine). Disruption of the shikimic pathway inhibits photosynthesis, cellular growth, and nucleic acid production. Depending on the species of plant, weather, and season, glyphosate toxicity occurs within a week of application. Plants wilt and yellow, and eventually die. There is some evidence of a hormetic response (i.e., increased vigor as a result of treatment) at very low concentrations of glyphosate.[5, 190] There is substantial variability in the susceptibility of plants to glyphosate, and this report summarizes a representative sample of the available terrestrial plant studies.

For all herbicides, US EPA requires manufacturers to perform seedling germination and emergence and vegetative vigor studies in non-target plants (including effects on corn and soybean). Seedling germination studies involve submersion of seeds in solution containing the herbicide. Seedling emergence studies involve application of the test compound to soil containing seedlings. Both of these tests simulate the effects of herbicide-contaminated runoff on emergent vegetation. Vegetative vigor studies involve direct foliar applications to young plants and simulate the effects of spray drift.

Most grasses, broadleaf, and woody plants readily absorb glyphosate, distribute it through plant tissues and store the chemical in sensitive roots and stems. The evapotranspiration and growth activity of the plant affects how quickly and thoroughly the chemical is absorbed. Approximately 33% of foliar-applied glyphosate is absorbed within the first few hours.[5] Surfactants also affect absorption: 64% of glyphosate applied without a surfactant washes off plant tissue; 50% washes off with a surfactant.[5] Below ground, glyphosate adsorbs strongly to soils, preventing root uptake.

With the widespread increase in glyphosate use accompanying the advent of Roundup-Ready crops, many wild plants are acquiring glyphosate resistance.[191] About a dozen weed species have developed resistance (including Johnsongrass, rigid ryegrass, and horseweed) and have emerged in China, Brazil, Argentina and the United States. According to a Syngenta survey, 8% of US farmers say that glyphosate resistance is a problem in the entirety of their acreage.[192] Resistant plants, wild or genetically modified, move glyphosate to the leaf tips protecting sensitive roots and stems. By doing so, these plants sacrifice a small part of the plant to save the rest.[192]

The Terretox database includes more than 1,300 studies on glyphosate toxicity to plants. Studies usually record the percent of a plant damaged or fraction of plants killed as a function of the application rate in kg/ha pesticide. Since glyphosate is an herbicide, and thus we expect mortality and damage upon application, a summary of all the Terretox records seemed unnecessary. The application rates that killed 50% and 100% of experimental plants are the most directly comparable endpoints to $LD_{50}$ values available for other organisms. Glyphosate application rates ranging from 0.21-6.7 kg/ha were capable of killing 100% of a variety of plants including: wheat, oat, barley, purple crabgrass, devilgrass, panic grass cocklebur, Lamb's quarters, dandelion, meadow garlic and eastern white pine. Application rates ranging from 0.046-4.5 kg/ha were capable of killing 50% of a variety of plants including: ryegrass, Lamb's quarters, potato white fir, blackberry, quackgrass, ivy and sugar pine. Bryophytes and fungi have $EC_{50}$ values as low as 0.8 kg/ha (assumed to be technical grade glyphosate).[193] There do not appear to be patterns in toxicity by plant family or order, consistent with glyphosate's non-selective mechanism of action.

Studies on the effects of glyphosate residues in soil on seedling emergence for non-target plants evaluated by US EPA indicate that adverse effects are only observed at application rates of about 4–5 lb a.e./acre.[194] This apparently low toxicity is due to the adsorption of glyphosate to some soils, limiting its uptake by plants.

Drift studies cited by USFS 201[5] have measured the extent of damage to non-target plants from glyphosate drift at several different levels. One study simulated drift by applying 1%, 3%, 10%, 33% of the 1.121 kg/ha suggested application rate for glyphosate to soy plants.[195] The authors found that transient damage could be observed at 0.034 kg/hectare (or 3% of suggested application rates). At 33% of the application rate, more than 50% of the plant was damaged seven days after application. After 60 days, only 20% of the plant was damaged, but the height of the plant was stunted by 25%. Agricultural yield was less affected than the plant tissue.

Similar drift studies reported in the USFS 2011 risk assessment simulated drift using the same application rates and found that leaf area, shoot length, and visible damage were all affected by glyphosate applications of 0.34 kg/ha.[196a, b, c]

To quantify how far backpack-sprayer-applied glyphosate traveled, droplet deposition on absorbent paper and plant damage were measured at various distances from the target site.[197] The authors found that damage could be observed in dicotyledonous *Brassica nupus* and monocotyledonous *Poa annua* up to 10 meters away. USFS 2011 reports a study that did a similar experiment involving a larger number of species and found that a buffer of eight meters was sufficient to prevent significant plant mortality to non-target species.[198]

Concerns remain about the potential of glyphosate to affect populations of soil fungi such as *Phytophthera* that may have secondary effects on the incidence of Sudden Oak Death (see the following section), but there is not enough known about these effects to do a quantitative analysis of risk.

**Levels of concern for terrestrial plants:** For the Mount Sutro risk assessment, we used the USFS TRV for a seed emergence NOEC of 4.5 lb/acre for our analysis of glyphosate hazards to non-target plants (see Table 3-8 on page 3-61). Since glyphosate binds strongly to most soils, there is little uptake by other plants through root absorption,[199] and little threat to seedling germination. For vegetative vigor, we used the USFS TRVs for sensitive species tomato and radish, with a NOEC of 0.035 lb a.e./acre. For tolerant plants such as ryegrass, corn, and onions, we used the NOEC of 0.56 lb a.e./acre.

#### *3.3.2.D Soil Microbes*

The EPA does not require that soil microorganism studies be performed as part of the registration process. There are also no Terretox database records that address soil microorganisms specifically. However, there are numerous soil microbial studies reported by the USFS. Although microbes also have a shikimate pathway that is affected by glyphosate, microbial glyphosate toxicity appears to be low.[5] One long-term study suggests that repeated glyphosate use does not decrease soil fertility.

Glyphosate is readily metabolized by soil bacteria, which are capable of using glyphosate as a source of phosphorous, and in some cases as a source of carbon.[200] In soils, glyphosate is first degraded to AMPA, and then to water, carbon dioxide and phosphate (see Section 3.4.3.A).[201] Glyphosate can both inhibit microbial growth and act as a nutrient for some organisms. In addition, it has also been found to increase carbohydrate and amino acid concentrations in root exudates in soybeans.[202] The combined effect of these two factors influences the populations of soil bacteria and fungi, in some cases promoting microbial growth and in other cases inhibiting it.

There is some evidence that glyphosate may inhibit the growth of microorganisms in artificial media. Direct toxic effects have been observed in fungi at concentrations of 10 ppm[203] and decreased growth in algae and cyanobacteria at concentrations of 800-3,380 mg/L.[204] These effects were consistent with a review[205] suggesting that loss of the shikimic pathway could adversely affect microbes. However, some studies point to other reasons for reduced microbial growth. One study reported decreased growth in the nutrient-absorbing surface (extraradical mycelia) in the fungal symbiont *Glomus intraradices* after 14 days of exposure to 0.5 ppm glyphosate in artificial culture.[206] This decrease in mycorrhizal growth was attributed to the adverse effects of glyphosate on carrot plants grown in soils containing *Glomus intraradices*.

No long-term soil fertility decreases have been reported as a result of glyphosate application. Soil concentrations of 100 ppm of glyphosate or AMPA had no significant effect on soil denitrification.[207] One long term study noted no effects on soil fertility in repeated 1.5 kg/ha, applications over 14 years (although not directly stated, it is implied that this is glyphosate without a surfactant).[208]

In a mini-review from researchers at the Mississippi USDA, glyphosate's effects on biological nitrogen fixation were discussed.[209] The authors concluded that previous laboratory research demonstrated the potential for reduced nitrogen fixation in glyphosate-resistant soybean plants. Although the current project will not involve treating glyphosate-resistant plants, it is relevant to determine the impact of glyphosate on soil microbes which provide critical ecosystem functions.

The review found that soybean yield reductions due to reduced $N_2$ fixation have not been demonstrated. The authors focused on the symbiont *Bradyryhizobium japonicum* and mentioned that some bacteria in the nitrogen-fixing family Rhizobiaceae were not affected by glyphosate. In a later paper by the authors,[210] glyphosate-resistant soybean plants were shown to have reduced nitrate assimilation but relatively unchanged nitrogen fixation at application rates of 1.1 and 3.4 kg ae/ha. Reduced assimilation resulted in temporarily lower leaf nitrogen, increased plant protein and decreased plant oils. Although neither study suggests definitive whole plant or whole ecosystem alterations, these studies do suggest that glyphosate affects soil microbes and nutrient cycling.

When fungi are grown in soil media treated with glyphosate, no permanent changes in fungal populations and growth are observed. Application rates of 0.54 kg/ha showed decreased populations of soil fungi after 2 months, but no effect after 6 months.[5] Similarly, at 5 kg/ha of glyphosate, transient decreases in soil microbial activity were noted.[211] Application of 3.23 kg/ha did not affect soil fungi after 10-14 months. Several field studies have reported an increase in microbial activity after the application of glyphosate.[212] Although not directly stated in USFS 2011, it is implied that these studies used glyphosate without a surfactant.

Glyphosate treatments of soybean seedlings have been observed to temporarily increase the populations of *Pythium* fungi in the soil.[213] Popluations of both *Pythium* and *Fusarium* fungi increased in soils treated with glyphosate or in which plants treated with glyphosate were grown.[214] This effect was attributed to cell leakage caused by glyphosate treatment, which made the root environment more favorable for *Fusarium* and *Pythium* growth. In contrast, laboratory studies with *Phytophthera cinnamomi* showed that glyphosate inhibited fungal growth.[215]

This work may be relevant to the Mount Sutro project area if Sudden Oak Death (SOD) caused by *Phytophthera ramorum* exists on the Reserve. It is not clear how transferable the results from soybean experiments are to invasive weeds like broom in oak woodland environments. Broom, like soybean, is a legume with root nodules. Whether or not this would translate to any increase or decrease of SOD is unknown at this time. Further research is needed to determine whether glyphosate use on broom and other invasive weeds might affect soil populations of *P. ramorum* and whether application timing might limit either effect

**Levels of concern for soil microbes:** There are no soil microbe exposure models available, and since data are sparse and not representative of the full range of soil microorganisms, no TRV was selected. The units for soil microbe toxicity tests reported in Section 3.3.2.D are in kg/ha and can be compared directly to application rates that are being considered for the current project to estimate potential effects on soil microorganisms not evaluated in the risk assessment.

### 3.3.3 Aquatic Organisms

There is a substantial literature on the effects of glyphosate in both pure form and with surfactants on aquatic organisms. The EPA AQUIRE database gives a range of $LC_{50}$ values and subchronic toxicity levels for aquatic organisms. The use of surfactants in glyphosate products is a topic of particular concern. Many studies report that the surfactants in formulated glyphosate products are as toxic or more toxic than glyphosate alone.[5] The products that are most toxic

according to the US Forest Service are Credit Systemic, Credit, Glyfos, Glyphosate (a formulated product containing glyphosate and other ingredients), Glyphosate Original, Prosecutor Plus Tracker, Razor SPI, Razor, Roundup Original, Roundup Pro Concentrate, and Roundup UltraMax.[5] Less toxic products include: Aqua Neat, Aquamaster, Debit TMF, Eagre, Foresters' Non-Selective Herbicide, Glyphosate VMF, Roundup Biactive, and Roundup Custom.[5] Aquamaster, the product proposed for use by the UCSF, does not contain any additional surfactants. Additional discussion of surfactants can be found in Chapter 5 of this report.

#### *3.3.3.A Fish*

Estimates of exposure for fish were calculated for fish potentially exposed through herbicide runoff to the Oceanside and Southeast wastewater treatment plants (WWTPs). Human scenarios for consumption of contaminated fish were not considered in this risk assessment, because fish have not been reported to exist within the Mount Sutro Reserve.[216] Similarly, exposure to glyphosate for fish-eating birds was not considered because fish exposed through glyphosate runoff to the WWTPs would be exposed to such low concentrations that bioaccumulation is not a risk, since glyphosate does not bioaccumulate to a significant extent even at higher concentrations.[5] As a result, neither human nor bird exposures to glyphosate from consumption of contaminated fish are a significant source of exposure

The EPA requires acute fish toxicity studies as part of the chemical registration process. The RED contains roughly 35 fish studies and the AQUIRE database contains over 600 records of studies. Acute toxicity studies indicate that, technical glyphosate ranges from not acutely toxic to slightly toxic to fish, and that glyphosate formulations with surfactants can be slightly to highly acutely toxic. Glyphosate toxicity varies substantially depending on the product formulation, water hardness and pH.[5] For solutions of glyphosate without surfactants, the dominant factor contributing to toxicity is pH, with toxicity increasing at lower pH (more acidic conditions).

**Levels of concern for fish:** The USFS evaluated the effects of two formulations of glyphosate on aquatic life—one less toxic containing only glyphosate and one more toxic, representing Roundup containing POEA surfactant—on two surrogate species, a tolerant species and a sensitive species. The USFS also reported an acute and a chronic TRV, resulting in eight total TRVs for toxicity to fish. Since only the less toxic glyphosate formulation (with no toxic surfactant) is being considered for use in the Mount Sutro Reserve, only the four less-toxic TRVs are reported here. However, only the TRVs for sensitive fish were used in the Mount Sutro risk assessment to obtain a worst-case estimate of risks to fish. See Table 3-8 on page 3-61 for a summary of these values.

**Tolerant fish:** For tolerant species and less-toxic glyphosate formulations, the USFS uses an acute TRV of 21 mg/L, based on an $LC_{50}$ of 429 mg/L for rainbow trout[217] and divided by a factor of 20 to provide a surrogate NOAEC, according to US EPA's method for protecting endangered aquatic species.[8] The same value is used for the chronic TRV.

**Sensitive fish:** For more-sensitive fish species, USFS used an acute TRV for chum salmon of 0.5 mg/L based on an $LC_{50}$ of 10 mg/L for rainbow trout[218] and divided by a factor of 20 to

provide a surrogate NOAEC, according to US EPA's method for protecting endangered aquatic species.[8] The same value is used for the chronic TRV.

#### *3.3.3.B Amphibians*

The biological report for Mount Sutro indicates that the dense understory and leaf litter in the eucalyptus forest is likely to support common, urban-adapted amphibians such as the California slender salamander (*Batrachoseps attenuatus*) and the Sierran treefrog (*Pseudacris sierra*).[219] This risk assessment provides an estimate of risk to amphibians from use of herbicides in the Reserve.

Although the EPA does not require amphibian studies as part of the registration process, there is a considerable body of literature on the effects of glyphosate on amphibians. Additionally, in its review of glyphosate for potential effects on the California red-legged frog, US EPA evaluated a number of amphibian studies, but did not develop a TRV.[8]

In general, glyphosate is slightly more toxic to most amphibians than to fish. The active ingredient is rated not acutely toxic to slightly acutely toxic. Glyphosate formulated with a toxic surfactant ranges from slightly acutely toxic to highly acutely toxic. Two amphibian studies on a total of four species (*Rana clamitans*, *Rana pipiens*, *Bufo americanus*, *Xenopus laevis*) show that higher pH makes glyphosate formulations more toxic,[220a, b] but no studies showing the effects of water hardness were encountered. The IPA salt of glyphosate is less toxic to amphibians than glyphosate acid, a result that is problably due to the buffering action of the salt compared to the acid.[221] Mesocosm studies by Rick Relyea that attempt to mimic field conditions show potential for high concentrations and resulting adverse effects on amphibians in locations where habitat is oversprayed. In several field studies, glyphosate treatment after clear-cutting did not appear to reduce amphibian populations.

**Laboratory studies: Acute toxicity**

The USFS utilizes highlights studies that demonstrate the higher toxicity of glyphosate acid, with $LC_{50}$ values from 81.2–121 mg a.e./L, compared to the IPA salt, which produces $LC_{50}$ values >343 to >466 mg a.e./L, with no mortality observed in these studies.[222] This study did not evaluate sublethal effects and there do not appear to be detailed comparative studies on sublethal effects of glyphosate acid and the IPA salt. The USFS takes these $LC_{50}$ values—rounded to 340 and 470 mg a.e./L and uses them as the acute NOAECs for sensitive and tolerant amphibians with no modification.

In another study, the $LC_{50}$ values were compared to $LC_5$ values for both glyphosate and Roundup for the African clawed frog (*Xenopus laevis*).[223] Glyphosate IPA, in the absence of a surfactant, has an $LC_{50}$ of 5,407 mg a.e./L and an $LC_5$ of 3,779 mg a.e./L. In contrast, the same endpoints for Roundup are 6.9 mg a.e./L ($LC_{50}$) and 4.7 mg/L ($LC_5$) and for the surfactant POEA alone are 2.7 mg/L ($LC_{50}$) and 2.2 mg/L ($LC_5$).

The AQUIRE database includes much lower $LC_{50}$ values for amphibians exposed to glyphosate alone, but similar $LC_{50}$ values for the formulated products (see Tables D-10 and D-11). The median 48-hour $LC_{50}$ value for five glyphosate studies for four amphibian species was 343 mg a.e./L. For formulated products with surfactants, the median value for 40 studies over 10

species was 5.5 mg a.e./L. The lowest $LC_{50}$ for a formulated product was 0.41 mg/L for *Rana sylvatica* (in a tank that also contained predators),[224] lower than the lowest NOEC (0.61 mg/L for abnormal development in *Rana clamitans*).

A review of five species of tadpoles exposed to various glyphosate formulations[225] (*Helioporus eyrei*, *Limnodynastes doralis*, *Litoria moorei*, *Crinia insignifera*) yielded 48-hour $LC_{50}$ values of 328 to > 494 mg a.e./L for Roundup Biactive, a formulation containing a non-POEA surfactant that is approved for use in water. Roundup ($LC_{50}$ 2.9–51.8 mg a.e./L) and Touchdown ($LC_{50}$ 9.0–16.1 mg a.e./L) were much more toxic. In the same study, the $LC_{50}$ values for newly metamorphosed frogs exposed to Roundup ranged from 49.4 to 51. 8 mg a.e./L. These tadpoles were significantly less sensitive to glyphosate compared to *Pseudacris triseriata* and *Rana blairi* tadpoles;[226] however, other studies (discussed below) support the observation of higher sensitivity of most amphibians to glyphosate formulations with surfactants.

A study of the toxicity of a POEA-containing Roundup formulation to 13 species of larval amphibians was reported in 2009.[227] Ninety-six hour $LC_{50}$ values for frogs ranged from 0.8 to 2.0 mg a.e./L; for salamanders, values ranged from 2.7 to 3.2 mg a.e./L. Very little difference in sensitivity between species was noted.

### Laboratory studies: Chronic toxicity

In the only available chronic study, glyphosate concentrations of 1.8 mg/L caused no observable effects in the growth and survival of *Rana pipiens* exposed for 42 days, from Gosner stage 25 through Gosner stage 42.[228] This is the NOAEC the chronic TRV is based upon. Because no other doses and time periods were tested, it is not possible to predict the concentrations at which adverse effects may occur. The same study found that POEA alone and Roundup containing POEA caused significantly higher mortality than glyphosate alone and reduced growth at concentrations of 0.6 mg/L. POEA and Roundup also disrupt sexual development and the ratio of male:female adult frogs, while glyphosate does not.

### Mesocosm and field studies

Multiple mesocosm and field studies on the effects of Roundup on amphibians. These studies may not be especially relevant to the Mount Sutro project, since no Roundup or POEA surfactants are being considered for potential use on Mount Sutro. However, the studies provide good examples of research that considers ecosystem effects and exemplifies potential controversies associated with glyphosate. Of particular interest are Professor Rick Relyea's "multi-tiered studies" which look at Roundup at a range of concentrations and experimental conditions. Relyea's studies examine: 1) how different Roundup concentrations—alone and in combination with other chemicals—affect five tadpole species' growth and survival in the laboratory;[229] 2) how Roundup affects the ability of six tadpole species to survive in the presence or absence of predator stress;[230] 3) how Roundup affects three tadpole species in artificial "ecosystems", or mesocosms, with invertebrate and vertebrate predators;[231] 4) how tadpole survival is affected by Roundup in different mesocosms which include different types of soil;[224] and 5) how the maximum application rate suggested on the Roundup label affects mesocosms lacking predators.[232]

The first study by Relyea[229] found that Roundup kills 30–60% of *Rana clamitans*, *Rana catesbeiana*, and *Bufo americanus* tadpoles at concentrations of 1.5 mg a.e./L. The particularly

insensitive *Rana pipiens* only experiences about 15% mortality at this concentration. If the concentration of Roundup is reduced to 0.74 mg a.e./L, mortality is 5-15%. Mortality is unchanged with an additional 0.74 mg a.e./L of carbaryl or malathion. The presence of diazinon in conjunction with glyphosate does increase mortality because diazinon is more toxic than glyphosate; however, "chemical cocktails" of more than one pesticide examined in this study were no more toxic than their individual constituents. At both 0.74 and 1.5 mg a.e./L of diazinon added to glyphosate there was considerable reduction in tadpole growth. The reduction in growth was comparable to the growth reduction as a result of diazinon alone.

The second study by Relyea found that the ability of six tadpole species (*Rana clamitans, Rana sylvatica*, *Rana catesbeiana, Rana pipiens*, *Hyla versicolor*, and *Bufo americanus*) to survive Roundup exposure was reduced considerably in the presence of predatory stress from the red-spotted newt, or *Notophthalmus viridescens*.[230] Newts were not in direct contact with the tadpoles, but instead emitted chemical cues into the tadpoles' water. In the absence of the newt signal, Roundup $LC_{50}$ values ranged from 1.1–11.4 mg a.e./L compared to 0.41–1.86 mg a.e./L in the presence of predatory cues.

Relyea's third study created whole-amphibian mesocosms with predators.[231] Mesocosms included *Hyla versicolor, Bufo americanus* and *Rana pipiens* tadpoles, zooplankton and predatory newts (*Notophthalmus viridescens*), predatory beetles (*Dytiscus* sp.) or no predators. The study found that Roundup concentrations of 0.96 mg a.e./L directly decreased survival by 40%, but there were no indirect effects of either predator. The fourth study found that the addition of either sand or loam soil did not affect the toxicity of glyphosate compared to tanks with no soil. This result is contrary to two studies[233] that suggest that sediments make glyphosate and POEA inaccessible, and thus less toxic, to aquatic life. However, the type of sediment matters (see Section 3.4.2 below).

Controversy surrounds the final Relyea study[232] which looked at the effects of a variety of chemicals applied at the maximum rate to mesocosms that included predators.[234] Three primary criticisms were leveled by Monsanto scientists: (1) the study is not as influential as it claims, (2) the application rate is too high relative to actual ecosystem concentrations, and (3) there were methodological issues with the study. The first criticism revolves around the fact that Relyea did not reference articles that were conducted by scientists involved with all Roundup risk assessments prior to 2005. Often these risk assessments were published in collaboration with Monsanto. However, the reason these studies were not referenced in Relyea's work is that they had not been published in the peer-reviewed literature at the time of Relyea's initial submission. The second criticism states that the maximum application rate reported on the Roundup label is never applied to water bodies and therefore is not a reasonable concentration for a toxicity study. Numerous studies have reported temporary pulses of chemicals that approach, but rarely exceed, the application rate used by Relyea.[235] Furthermore, as stated in a previous paper by Relyea's critics, "small wetlands occurring within the target area are likely to be directly oversprayed," suggesting that Relyea's estimate of high aquatic concentrations are indeed realistic.[236] The third criticism, that there were methodological errors in the control treatment, was adequately addressed in a rebuttal by Relyea.[234]

Relyea's studies have been compared to a study conducted by Joel Trumbo at the CA Department of Fish and Game where a vegetation-free pond was treated with high concentrations

of Rodeo in combination with the surfactant R-11. The R-11 product contains nonylphenolethoxylate (NPE) and nonylphenol (NP).[237] The concentrations of glyphosate, NPE, and NP were monitored in the pond for eight days after treatment, using composite sampling of the surface water in the pond. Surface sampling should provide a worst-case estimate of initial concentration, since pesticide applications to water bodies result in the formation of a concentrated layer of herbicide/surfactant on the surface of the water. This phenomenon would be exacerbated in thermally stratified water bodies or very shallow waters like vernal pools frequently used as breeding habitat by frogs.

Concentrations in the pond peaked in one location at 3.1 mg/L glyphosate (mean 1.83 mg/L), 1.8 mg/L NPE (mean 1.1 mg/L) and 0.03 mg/L NP (mean value) one hour after the applications and declined rapidly within the first 24 hours to 0.3 mg/L glyphosate, 0.4 mg/L NPE and 0.005 mg/L NP. The observed difference between the composite mean and the maximum concentrations suggests that there was some inhomogeneity in the distribution of the chemicals in the pond. Laboratory tests to determine 96-hour $LC_{50}$ values for *Rana pipiens* for the mixture of glyphosate, NPE and NP were conducted separately, and these $LC_{50}$ values (6.5 mg/L glyphosate, 1.7 mg/L NPE) were compared to measured concentrations in the pond. The author concluded that the mix of Rodeo and R-11 surfactant would not pose an acute toxicity hazard to tadpoles, even at the comparatively high application rates used in the study. This conclusion is not inconsistent with Relyea's work; the two studies taken together indicate that sub-lethal effects such as susceptibility to predation may play a more significant role in amphibian mortality than the acute toxicity of the applied chemicals.

Another field study reported the effects of glyphosate application on populations of six species of amphibians.[238] The effects of both clear-cutting and glyphosate were measured by comparing the capture rates of six amphibian species at the different sites. Red alder was removed from two sites in the Oregon coast range. One site received follow-up glyphosate treatment and a third site was kept as an untreated control. Prior to treatments, a survey of the amphibian species in the area was conducted. The survey species included: rough-skin newt, ensatina salamander, Pacific giant salamander, Dunn's salamander, western redback salamander, and red-legged frog. Clear-cutting reduced amphibian populations regardless of whether glyphosate was used, but there was no difference between glyphosate treated clear-cut sites and untreated clear-cut sites.

Perkins et al 2000[223] looked for teratogenic effects of Roundup and Rodeo on *Xenopus laevis*, or the African clawed frog. Only groups that were exposed to lethal concentrations of glyphosate IPA, Roundup, and the POEA surfactant reported statistically significantly higher levels of abnormalities. The abnormalities linked to exposure include uncoiling of the gut, edema, blistering, abnormal pigmentation, and axial twisting in control embryos. See Table D-12 for a summary of sublethal effects of glyphosate on amphibians.

**Studies of Aquamaster combined with the surfactants Competitor and Agri-Dex:** The Santa Clara Valley Water District sponsored a study of the toxicity of the product Aquamaster (containing only glyphosate and water) and mixtures of Aquamaster with the surfactants Competitor and Agri-Dex to the California toad, *Bufo boreas halophilus*, a species native to the area.[239] This study is potentially the most relevant to the Mount Sutro project, since Competitor is one of the adjuvants selected for potential use with Aquamaster. All of the mixtures tested,

including those containing surfactants, are classified as "Not acutely toxic," according to the standard aquatic toxicity ranking schema (see Table 2-6).

In the study, concentrations representing actual tank mixtures of Aquamaster and the two surfactants were tested. Based on four replicates of six concentrations, the 24-hour $LC_{50}$ value for Aquamaster alone was determined to be 8,245 mg a.i./L; the $LC_{50}$ for a 2:1 mixture of Aquamaster and Agri-Dex was 5,092 mg a.i./L; and the $LC_{50}$ for a 2:1 mixture of Aquamaster and Competitor was 854 mg a.i./L. Forty-eight hour $LC_{50}$ values were 6,411 mg a.i./L for Aquamaster alone; 4,254 mg a.i./L for the Aquamaster/Agri-Dex mixture; and 711 mg a.i./L for the Aquamaster/Competitor mixture.

The results of this study are muddied by the lack of discussion of how the $LC_{50}$ was derived from the data and the lack of a control study on the surfactants alone; however, the data do indicate that the toxicity of glyphosate to *B. boreas halophilus* is enhanced by addition of the two surfactants. Mixtures containing Competitor were approximately 10 times more toxic than Aquamaster alone and mixtures containing Agri-Dex were approximately 1.6 times more toxic. The test species *B. boreas halophilus* appears to be one of the least-sensitive amphibians to glyphosate, with the observed $LC_{50}$ higher than any value for amphibians exposed to glyphosate in US EPA's entire AQUIRE database.[9]

The US EPA evaluated the effects of two formulations of glyphosate on amphibians—one less toxic containing only glyphosate and one more toxic, representing Roundup containing POEA surfactant.[8] Since only the less toxic glyphosate formulation (with no surfactant) is being considered for use in the Mount Sutro Reserve, only the less-toxic TRVs are discussed here. Because of the wide variation in amphibians' sensitivity to glyphosate and the limited range of amphibians tested, US EPA decided to use more a more conservative acute endpoint from a freshwater fish study. Thus, an acute 96-hour $LC_{50}$ for bluegill sunfish of 43 mg a.e./L was used as the critical toxicity endpoint, adjusted by a factor of 20 to account for the use of an $LC_{50}$ instead of a NOAEC, resulting in an acute amphibian TRV of 2.2 mg/a.e./L.

**Levels of concern for amphibians:**
For the Mount Sutro risk assessment, we used the US EPA acute TRV of 2.2 mg a.e./L, based on a 96-hour $LC_{50}$ for bluegill sunfish of 43 mg/L and divided by a factor of 20 to provide a surrogate NOAEC, according to US EPA's method for protecting endangered aquatic species.[8] We utilized the EPA acute value instead of that proposed by the USFS, which was less protective, with a TRV of 340–470 mg a.e./L for sensitive and tolerant amphibians, respectively. For the chronic glyphosate TRV, we used the lowest (and only) chronic NOEC of 1.8 mg a.e./L for *Rana clamitans*, the same value that US EPA and the USFS used in their assessments. See Table 3-8 on page 3-61 for a summary of the TRVs used in the Mount Sutro project.

#### *3.3.3.C Aquatic Invertebrates*

Overall, glyphosate is rated not acutely toxic to moderately acutely toxic for aquatic invertebrates. Field studies suggest that glyphosate is not acutely toxic at normal application rates.

US EPA's recent Effects Determination for glyphosate utilizes a laboratory study on midge larvae to determine the acute endpoint.[8] For the common midge, *Chironomus plumosus*, the 48-hour $LC_{50}$ for 96.7% technical grade glyphosate is 53 mg a.e./L, which gives it a ranking of slightly toxic. This value is divided by a factor of 20 for endangered species protection, resulting in a TRV of 2.6 mg a.e./L. A chronic study on *Daphnia magna* provided a NOAEC of 49.9 mg a.e./L that US EPA used as the chronic toxicity endpoint.

The toxicity of formulated glyphosate products to aquatic invertebrates can be much greater, with $LC_{50}$ values as low as 2.2 mg/L (moderately acutely toxic). The AQUIRE database (see Tables D-13 and D-14) and USFS give comparable $LC_{50}$ values for formulated products. For *Ceriodaphnia dubia*, AQUIRE reports an $LC_{50}$ between 4 and 79 mg/L, with a median of 22 mg/L for Roundup. USFS 2011 [240] reports a mortality $EC_{50}$ value for a formulation of glyphosate IPA (48%) and an oxide-coco-amide-propyl dimethyl-amine surfactant (15%) of 66 mg/L in *D. spinulata* and 62 mg/L in *D. magna*.

Various field studies have not noted any remarkable effects of glyphosate on aquatic invertebrates. Application rates of 1 L Rodeo/ha for control of purple loosestrife produced no adverse effects to aquatic invertebrates.[241] USFS reports: (1) no indication of lethality in two water hyacinth weevils, *Neochetin eichhorniae* and *N. bruchi* at application rates of 0.94 or 1.48 kg a.i./ha as glyphosate IPA (Rodeo),[242] (2) no differences in invertebrate survival in a forest mesocosm over an 8-day period after sprays of 2.2 kg/ha, 22 kg/ha and 220 kg/ha of Rodeo,[243] and (3) no indication of short- or long-term (119 days) invertebrate effects after the application of a 4.7 L/ha Rodeo and 1 L/ha X-77 mixture to control of smooth cordgrass in an estuarine mudflats.[244] Glyphosate sprayed to the estuarine mudflat is quickly flushed from the surrounding tidal waters but remains in sediments (28-59% of applied glyphosate remained after 119 days) and vegetation (1-9% of applied glyphosate remained after 28 days).[245]

As for fish, the same issues of water hardness, pH, and surfactant concentrations affect the toxicity of glyphosate to aquatic invertebrates. The USFS notes that "*the high variability in toxicity of the surfactant formulations to daphnids must be acknowledged*." Indeed, the AQUIRE database reports a range of $EC_{50}$ values from 1 mg/L to greater than 5,000 mg/L for all invertebrates in the collection of glyphosate studies.

**Levels of concern for aquatic invertebrates:** For the Mount Sutro risk assessment, we used the US EPA acute TRV of 2.7 mg a.e./L, based on a 96-hour $LC_{50}$ for *Chironomus plumosas* of 52.7 mg/L and divided by a factor of 20 to provide a surrogate NOAEC, according to US EPA's method for protecting endangered aquatic species.[8] We utilized the EPA value instead of that proposed by the USFS for both acute and chronic exposure, which was less protective (TRV of 210 mg a.e./L). For the chronic glyphosate TRV, we used US EPA's NOAEC for *Daphnia magna* 49.9 mg a.e./L. See Table 3-8 on page 3-61 for a summary of the TRVs used in the Mount Sutro project.

#### *3.3.3.D Aquatic Plants*

The toxicity of glyphosate to aquatic plants and algae varies considerably. However, aquatic plant toxicity endpoints are in the range of slightly to moderately acutely toxic, with a few studies suggesting that glyphosate is highly toxic to aquatic plants. Here, we evaluate only those

studies related to non-vascular plants like algae, since macrophytes like duckweed are not anticipated to exist on Mount Sutro due to the ephemeral nature of Woodland Creek.

The toxicity of glyphosate alone (no surfactants) to algae is variable, depending on test species, experimental conditions (e.g. length of study, form of glyphosate used) and water characteristics (e.g., pH), with $EC_{50}$ values (based on growth) ranging from a low of 5.3 mg/L for *Pseudokirchneriella subcapitata* (now known as *Selenastrum capricornutum*) to a high of 1,082 mg/L for *Chorella pyreniodosa.*[246] US EPA listed a number of studies on alage for glyphosate alone, with $EC_{50}$ values ranging from 11.4–37.3 mg a.e./L. NOAECs are not always reported, but those that are are in the range of 1.7–18.5 mg a.e./L. US EPA utilized a 4-day $EC_{50}$ study using *Selenastrum capricornutum* (based on reduced growth) of 12.1 mg/L in their assessment of potential effects on the California red-legged frog.[9]

Studies designed to mimic field exposure yielded different results than acute toxicity tests. Periphyton exposed to low glyphosate concentrations (0.0019–0.2874 mg/L) experienced increased growth rates.[247] The authors of the study hypothesize that algae use glyphosate as a phosphorous source, contributing to eutrophication. In a study designed to mimic direct overhead spraying of ponds, phytoplankton and zooplankton experienced no adverse effect after an application of Roundup at a rate of 0.43 kg/ha.[248]

**Levels of concern for aquatic plants:** For the Mount Sutro risk assessment, we used the US EPA acute TRV of 12.1 mg a.e./L, based on a 4-day $EC_{50}$ for *Selenastrum capricornutum* for the aquatic plant hazard quotient calculations.

### 3.3.4 Data Gaps

Because of glyphosate's extensive use over the past 34 years, a considerable body of literature has been amassed focusing on potential toxicity to wildlife. Realistically, the toxicity literature on the active ingredient glyphosate is as good as can be expected. However, there is still uncertainty regarding the toxicity of various surfactants used in conjunction with glyphosate. The identity and concentration of surfactants is viewed as proprietary information by herbicide manufacturers. "Inert" ingredients like surfactants are not reported on product labels and toxicity information is not required. Although the USFS 2011[249] has a table outlining the toxicity of various glyphosate products, it is difficult to draw precise conclusions about toxicity without knowing all of the components in the formulated product and their concentrations.

Acute toxicity information was available for multiple surrogate species for all wildlife taxa in the Mount Sutro Reserve. Acute toxicity values vary substantially between species and tests. More information describing this variability would better define the range of toxicity. NOELs or LOELs were available for the sub-lethal effects of glyphosate for at least one surrogate species. Some sub-lethal toxicity information was available for all taxa. However fewer replicates were available for sub-lethal effects and rarely were reproductive, carcinogenic, developmental, histological and endocrine toxicity information available for all taxa. Reproductive toxicity was available for mammals, birds, and invertebrates. Carcinogenic and/or genetic toxicity data were available for mammals and fish. Developmental toxicity was available for mammals, birds, and amphibians. Histological information was available for mammals and fish.

Robust field measurements of the effects of glyphosate in natural settings are rare. A few studies addressed issues of competition and trophic interactions to glyphosate.[230, 231, 232] Several others compared species richness and productivity in field sites where glyphosate was applied to sites where glyphosate was not applied.[238] Several studies addressed "chemical cocktails" where species were exposed to more than one herbicide at a time.[229, 250] More field studies like these would help clarify the differences between laboratory and field toxicity of glyphosate.

More research is urgently needed to determine whether glyphosate affects growth of the soil fungus *Phythophthera ramorum* that causes Sudden Oak Death.

**Table 3-8: Comparison of Glyphosate Toxicity Reference Values (TRVs) Used in USFS and Mount Sutro Risk Assessments**

| | | | USFS | | | | Mount Sutro | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Exposure Type** | | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in USFS Risk Assessment** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in Mt Sutro Risk Assessment** |
| **Humans** | | | | | | | | | | |
| | acute RfD | | NOAEL (rabbit) | 175 mg/kg-day | ÷100[a] | 2 mg/kg-day | NOAEL (rabbit) | 175 mg/kg-day | ÷100[a] | 2 mg/kg-day |
| | chronic RfD | | NOAEL (rabbit) | 175 mg/kg-day | ÷100[a] | 2 mg/kg-day | NOAEL (rabbit) | 175 mg/kg-day | ÷100[a] | 2 mg/kg-day |
| **Mammals** | | | | | | | | | | |
| | acute | | NOAEL (rat) | 500 mg/kg-day | None | 500 mg/kg-day | NOAEL (rat) | 500 mg/kg-day | None | 500 mg/kg-day |
| | chronic | | NOAEL (rat) | 500 mg/kg-day | None | 500 mg/kg-day | NOAEL (rat) | 500 mg/kg-day | None | 500 mg/kg-day |
| **Birds** | | | | | | | | | | |
| | acute | | NOEC (diet, mallard) | 5,000 mg/kg-day | X 0.3[b] | 1,500 mg/kg-day | NOEC (diet, mallard) | 5,000 mg/kg-day | X 0.3[b] | 1,500 mg/kg-day |
| | chronic | | NOAEL (diet, bobwhite)[e] | 830 mg/kg-day | X 0.07[b] | 58 mg/kg-day | NOAEL (diet, bobwhite)[e] | 830 mg/kg-day | X 0.07[b] | 58 mg/kg-day |
| **Insects** | | | | | | | | | | |
| | honeybees | | NOEL (oral) | 0.100 mg/bee | ÷0.000116[c] | 860 mg/kg-day | NOEL (oral) | 0.100 mg/bee | ÷0.000116[c] | 860 mg/kg-day |
| | | | NOEL (dermal) | 0.100 mg/bee | ÷0.000116[c] | 860 mg/kg-day | NOEL (oral) | 0.100 mg/bee | ÷0.000116[c] | 860 mg/kg-day |
| **Terrestrial Plants** | | | | | | | | | | |
| | vegetative vigor, tolerant | | NOEC | 0.56 lb/acre | None | 0.56 lb/acre | NOEC | 0.56 lb/acre | None | 0.56 lb/acre |
| | vegetative vigor, sensitive | | NOEC | 0.035 lb/acre | None | 0.035 lb/acre | NOEC | 0.035 lb/acre | None | 0.035 lb/acre |
| | seed emergence | | NOEC | 4.5 lb/acre | None | 4.5 lb/acre | NOEC | 4.5 lb/acre | None | 4.5 lb/acre |
| **Fish[d]** | | | | | | | | | | |
| | acute, a.i., | tolerant | $LC_{50}$ (rainbow trout) | 429 mg/L | ÷20[f] | 21 mg/L | $LC_{50}$ (rainbow trout) | 429 mg/L | ÷20[f] | 21 mg/L |
| | chronic, a.i. | tolerant | $LC_{50}$ (rainbow trout) | 429 mg/L | ÷20[f] | 21 mg/L | $LC_{50}$ (rainbow trout) | 429 mg/L | ÷20[f] | 21 mg/L |
| | acute, a.i. | sensitive | $LC_{50}$ (chum salmon) | 10 mg/L | ÷20[f] | 0.5 mg/L | $LC_{50}$ (chum salmon) | 10 mg/L | ÷20[f] | 0.5 mg/L |
| | chronic, a.i. | sensitive | $LC_{50}$ (chum salmon) | 10 mg/L | ÷20[f] | 0.5 mg/L | $LC_{50}$ (chum salmon) | 10 mg/L | ÷20[f] | 0.5 mg/L |

| | | USFS | | | | Mount Sutro | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Exposure Type** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in USFS Risk Assessment** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in Mt Sutro Risk Assessment** |
| **Amphibians** | | | | | | | | | |
| | acute, a.i. | NOEC (frogs, 3 species) | 343 mg/L | None | 343 mg/L | $LC_{50}$ (bluegill sunfish) | 43 mg/L | ÷20[f] | 2.2 mg/L |
| | chronic, a.i. | NOEC (*R. pipiens*) | 1.8 mg/L | None | 1.8 mg/L | NOEC (*R. pipiens*) | 1.8 mg/L | None | 1.8 mg/L |
| **Aquatic Invertebrates** | | | | | | | | | |
| | acute | $LC_{50}$ (*Chironomus plumosas*) | 53.2 mg/L | ÷20[f] | 2.7 mg/L | $LC_{50}$ (*Chironomus plumosas*) | 53.2 mg/L | ÷20[f] | 2.7 mg/L |
| | chronic | $LC_{50}$ (*Chironomus riparius*) | 4,140 mg/L | ÷20[f] | 210 mg/L | NOEC (*Daphnia magna)* | 49.9 mg/L | None | 49.9 mg/L |
| **Aquatic Plants** | | | | | | | | | |
| | algae | $EC_{50}$ | 590 mg/L | ÷10[f] | 59 mg/L | $EC_{50}$ | 12.1 mg/L | None | 12.1 mg/L |

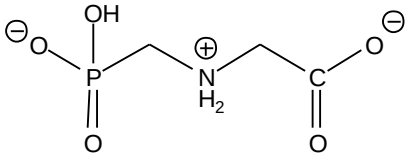
[a] For the human RfD, the animal NOAEL was divided by an interspecies uncertainty factor of 10 and an intraspecies uncertainty factor of 10, equivalent to dividing by 100.
[b] The dietary $LC_{50}$ in mg of chemical per kg of food was multiplied by 0.3 kg food/kg body weight for bobwhite quail for acute dosing and 0.07 kg food/kg body weight for chronic dosing to obtain an $LD_{50}$ in units of mg of chemical per kg body weight.
[c] The $LC_{50}$ of 50 µg/bee was converted to a dose in mg/kg by dividing by the USFS estimate of body weight of a bee: 0.000116 kg.
[d] There are no fish on Mount Sutro; however, the runoff water eventually drains to the San Francisco Bay and Pacific Ocean, where fish may be exposed.
[e] Because there were no acute NOECs, the chronic NOEC was used.
[f] The adjustment factors of 10 (mammals and birds) and 20 (terrestrial invertebrates and aquatic animals) are used by the US EPA in evaluation of endangered species effects when there is only an $LD_{50}$ or $LC_{50}$ value available, not the preferred NOAEL or NOEC. These factors are based on a review of literature studies in which both $LD_{50}$ or $LC_{50}$ and NOAEL or NOEC values were available for comparison.

## 3.4 Environmental Fate of Glyphosate

### 3.4.1 Overview

Glyphosate (CAS number 1017-83-6) is an organophosphonate herbicide, with empirical formula of $C_3H_8NO_5P$ and chemical structure shown below. Glyphosate is usually formulated as a sodium or potassium salt or as an amine or trimethylsulfonium salt of the carboxylic acid. Once in an aqueous environment, salts of glyphosate behave similarly to glyphosate itself, thus this review will report studies that involve both glyphosate and glyphosate salts. The physical properties of glyphosate are summarized in Table 3-9 below.

In the most biologically relevant pH range of 5 to 9, the tri-protic weak acid glyphosate exists in the form shown below.




In aqueous solution, the phosphate (-PO3H2) and carboxylate (-COOH) groups in glyphosate participate in acid-base equilibria with water, losing or gaining a proton ($H^+$) depending on solution pH. The form of glyphosate at a given pH is dictated by the acid dissociation constants (pKa) as shown in Figure 3-1 below.[10] At different soil pH values, the predominant form of glyphosate will govern the ability of the compound to bind to soils and be transported in water.

**Table 3-9: Chemical and Physical Properties of Glyphosate**

| Property | Glyphosate | Glyphosate IPA salt |
|---|---|---|
| **CAS number** | 1071-83-6 | 38641-94-0 |
| **EPA PC code** | 417300 | 103601 |
| **Molecular weight (g/mol)** | 169.09 | 228.22 |
| **Water solubility (mg/L at ~25°)** | 11,600 | 15,000 |
| **Half-life (days)** | 44–60 | 44–60 |
| **Hydrolysis** | 35 | 35 |
| **Anaerobic** | 22 | 22 |
| **Aerobic** | 96 | 96 |
| **Field dissipation** | 3–174 | 3–174 |
| **Vapor pressure (mm Hg at ~25°C)** | $< 7.5 \times 10^{-8}$ | --- |
| **$K_{oc}$ (mL/g)** | 554–34,000 | 554–34,000 |
| **$K_{ow}$** | 0.000316 | --- |
| **$K_H$ (atm-$m^3$/mol at ~25°C)** | $< 1.44 \times 10^{-12}$ | $< 1.44 \times 10^{-12}$ |

*Data source:* References 251, 252, 253.

### 3.4.2 Water Solubility and Soil Binding of Glyphosate

The parent acid glyphosate is a solid at room temperature and is highly water soluble (11,600 mg/L at 25°C). The octanol-water partition coefficient, log $K_{ow}$, is -2.8 to

-3.5,[10, 253] indicating high solubility in water relative to organic solvents and low potential for bioaccumulation. The IPA salt of glyphosate has higher water solubility (15,000 mg/L at 25°C).

The organic-carbon-adjusted soil adsorption coefficient ($K_{oc}$) of glyphosate ranges between 554–34,000 mL/g.[5] The magnitude of this value indicates that, in a mix of soil and water, glyphosate preferentially binds to soils, with little remaining dissolved in solution. Interestingly, the observed range for $K_{oc}$ is quite large compared to other pesticides. A number of studies on the different factors influencing glyphosate binding to soil have been performed to explore this phenomenon. The results indicate that glyphosate adsorption is governed mainly by binding to the mineral phase of soils.[254, 255] Glyphosate sorption increases in soils with low phosphate concentrations, and high availability of phosphate binding sites such as multivalent cations, especially trivalent iron and aluminum (oxides or hydroxides). Glyphosate sorption can occur at both low and high pH. There is only a weak correlation between glyphosate binding and soil organic matter, suggesting that the primary effect of organic matter is blocking of sorption sites on clay minerals. Thus the use of $K_{oc}$ to quantify the adsorption of glyphosate is not an accurate descriptor of the adsorption processes.[254]

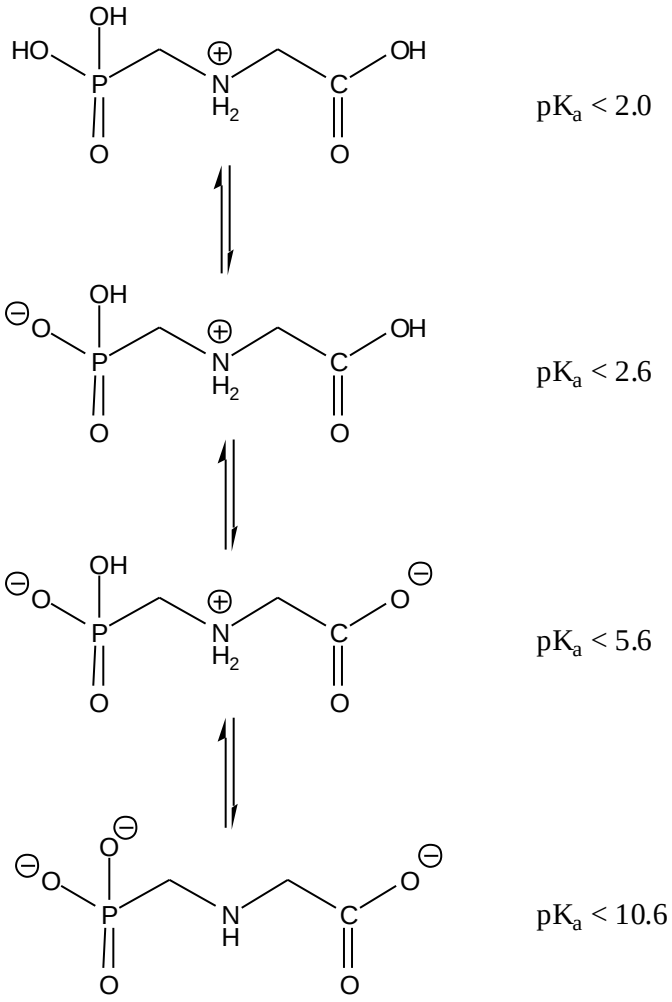



**Figure 3-1:** The ionic form of glyphosate is dependent on pH.

The precise relationship between all the pertinent glyphosate binding factors is still an area of active research.[256] However, it is clear that the presence of soil/sediments in aqueous solutions containing glyphosate reduces the effective herbicidal concentration and may also reduce the bioavailability of glyphosate.

### 3.4.3 Persistence of Glyphosate

Glyphosate and its primary degradation product aminomethylphosphonic acid (AMPA) are moderately persistent in the environment, with measured half-lives ranging from a few days to two years. On average, the half-life is ~1.5–2 months. Table 3-10 provides half-lives for specific studies under a variety of different conditions, and some of the more relevant studies are summarized briefly below.

In sterile, buffered, aqueous solution in the laboratory, glyphosate degrades primarily by hydrolysis, with a chemical half-life of greater than 340 days.[10] The addition of calcium ions to solution increases the photodegradation rate and decreases the half-life of glyphosate to 4–>14 days. UV light does not substantially accelerate the degradation of glyphosate in sterile buffered solution.[10] Photolysis does not seem to be a major degradation pathway for glyphosate in soils.[10]

In natural settings, glyphosate is subject to microbial degradation, adsorption to sediments and dissipation by wind and water. Thus, dissipation half-lives in the field are typically less than those observed under sterile laboratory conditions. Depending on soil type, temperature, microbial populations, and availability of oxygen, half-lives range from 1.5 days to 2 years.[10]

The dissipation half-life of glyphosate and AMPA in water ranges from 7–14 days.[257] In a recent study by the San Francisco Estuary Institute, two low-volume canals were treated with glyphosate. Immediately following the application, glyphosate concentrations were measured at 1.8 mg/L, a concentration above the Levels of Concern (LOCs) for some aquatic species. Concentrations at four monitoring stations ranged from 0.037–0.820 mg/L in the few hours after the application, but were below LOCs for all species within 24 hours. When two sites with larger water volumes were treated, there were no LOC exceedances. No toxicity was found in bioassays with *Ceriodaphnia dubia* and fathead minnows.[258]

Compared to aqueous half-lives, soil half-lives of both glyphosate and AMPA are substantially longer, 2–197 days for glyphosate and 76–240 days for AMPA.[257] In an Oregon study, the dissipation half-life in loamy soils was 29 days with and 40 days without leaf litter.[259] A Swedish study of glyphosate half-life in forest soils gave a value of <50 days.[260] Monsanto studies show half-lives ranging from 3–174 days in a variety of soils at different soil pH and organic matter content.[261] Studies in three forest locations in Oregon, Michigan and Georgia (also by Monsanto) show that most dissipation half-lives are <120 days.[262] Glyphosate concentrations were higher in exposed soils compared to those with undisturbed litter, potentially attributable to higher microbial activity in litter. A summary of existing studies by the CA Department of Pesticide Regulation indicates an average soil field dissipation half-life of 44–60 days.[263]

**Table 3-10: Half-Life of Glyphosate Under Different Conditions**

| Conditions | Half-Life (days) | Type of Half-Life* | Comments | Reference |
|---|---|---|---|---|
| **Water: Glyphosate (CAS 1071-83-6)** | | | | |
| 35°C, pH 3, 5, 6, 9 | Stable | Hydrolysis | | 253, 6 |
| pH 5, 7, 9 and buffered | Stable | Photo-degradation under natural sunlight | | 253 |
| | >35 | Hydrolysis | | 253, 263 |
| Forest ecosystem surface water—ponds high in sediment | 1.5–11.2 | Field dissipation | | 253, 264, 265, 259 |
| Natural waters | 35–63 | | | 253, 6 |
| Pondwater | 12–70 | | Glyphosate is strongly sorbed to suspended organic and mineral matter. | 266 |
| 5–35°C, pH 5, 7, 9 | Stable | Hydrolysis | | 267 |
| Flooded silty clay | 7 | Aerobic | | 267 |
| | 5–14 | Lab and field | Sediment is the major glyphosate sink | 10 |
| BC coastal rainforest—perennial slow flowing stream water | 2 | Field dissipation | | 268 |
| BC coastal rainforest—sediment from slow flowing stream | 22 | | | 268 |
| Non-flowing pondwater and flowing water from 3 forest sites | 7 | Field dissipation | | 269 |
| Manitoba forest site spray zones | | Field study with 40L polyethylene basins | Study compared glyphosate concentrations in filtered and unfiltered pondwater samples | 270 |
| — filtered | | Little dissipation after 30 days | | |
| — unfiltered | 6 | | | |
| Pondwater (silty clay loam sediment), 23–25°C, pH 5.9–7.0 | 14 | Aerobic | | 271 |
| Pondwater (silty clay loam sediment), 20–27°C, pH 5.7–6.5 | 14 | Anaerobic | | 271 |

Cont. next page

| Conditions | Half-Life (days) | Type of Half-Life* | Comments | Reference |
|---|---|---|---|---|
| **Soil: Glyphosate (CAS 1071-83-6)** | | | | |
| 20-acre forest sites | 100 (118 for AMPA) | Field dissipation | Aerially applied at 3.75 lb ai/acre | 272 |
| Canadian forest site, sandy soil | 24 | Field dissipation | Dead wood, live brush, and vegetation removed with minimal disturbance of the 5-10 cm soil horizon | 273 |
| | 1–174 | Field studies | Strongly adsorbed to most soils, even those with lower organic and clay content | 266 |
| 25°C, sandy loam | 1.85 | Lab, aerobic | | 267 |
| 25°C, silt loam | 2.06 | Lab, aerobic | | 267 |
| | 0.9 | Aerobic | | 252 |
| 25°C, pH 7.3, sandy loam | 2 | Bio-degradation; Lab, aerobic | Technical grade glyphosate | 274 |
| 25°C, pH 7.5, silt loam | 2 | Bio-degradation; Lab, aerobic | Technical grade glyphosate | 274 |
| 32°C, pH 5.7, sandy loam | 130 | Greenhouse dissipation | Technical grade glyphosate | 275 |
| 32°C, pH 6.5, silt loam | 3 | Greenhouse dissipation | Technical grade glyphosate | 275 |
| 32°C, pH 7.0, silty clay loam | 25–27 | Greenhouse dissipation | Technical grade glyphosate | 275 |
| pH 3.5–3.7, sandy, humo-ferric, boreal soils | 20 (approx) | Field dissipation | | 276 |
| pH 4.2–4.9, sandy loam, sandy clay loam | 45–60 | Field dissipation | | 277 |
| pH 4.0–4.7, loam | 29–40 | Field dissipation | | 259 |
| Loamy sand | 3–4 | Field dissipation | | 278 |
| Sandy clay loam | 122–174 | Field dissipation | | 278 |

In 2011, the Marin Municipal Water District (MMWD) released a study in which the persistence of glyphosate and its potential impacts on the quality of surface water was evaluated in the Mt. Tamalpais watersheds.[279] Applications of Aquamaster plus Competitor surfactant (the same mixture that is proposed for use on Mount Sutro) were made to several plots, and concentrations of glyphosate were measured in runoff, soils, and treated plants. Applications were conducted at a rate of 2 lb a.e./acre in early June and samples were taken over the course of 87 days to measure the degradation rate of glyphosate and its degradation product AMPA. The half-life of glyphosate was determined to be 44 days and that of AMPA was found to be 46 days. These measurements support the choice of 45, 30 and 60 days for Central, Upper and Lower values of glyphosate half-life for the Mount Sutro project. Results from the soil sampling showed that glyphosate was distributed throughout the soil horizon, with most of the herbicide occurring in the top 0–6 cm of the soil, up to a maximum concentration of 2.5 μg/kg. Residues of 0.5 μg/kg were detected at 30 cm depth. AMPA was not detected below 18 cm. Runoff from the treated sites contained no measureable quantities of glyphosate or AMPA, an observation the authors attributed to the deep layer of plant litter in the treated areas and the strong adsorption of glyphosate to the litter and soil. Measurements of glyphosate in treated broom plants showed no significant changes over the study period, indicating that the half-life of glyphosate in treated plants is much longer than in soils or water, probably due to the absence of microbial activity in plant tissues.

Glyphosate can be transported away from an application site or degrade in soil, water and air through a number of different chemical or biological processes. The most important processes for dissipation of glyphosate are microbial biodegradation, complexation in water with ions, e.g., $Ca^{2+}$, $Mg^{2+}$, and $Fe^{+2/+3}$, sorption to sediments and soils, uptake by plants, and photodegradation in water. Figure 3-2 describes the various degradation pathways for glyphosate.

#### *3.4.3.A Microbial Degradation*

The primary route of glyphosate degradation in the environment is via microbial degradation in soil.[253] Under aerobic conditions, AMPA and glyoxylate are the primary degradation products. Further degradation yields carbon dioxide, phosphate, ammonia, and formaldehyde, where formaldehyde rapidly reacts with water and/or hydroxyl radicals to form methanol. AMPA degrades more slowly than glyphosate, and may also adsorb more strongly to soils.

Typically, the initial degradation rate is rapid, followed by a slower breakdown of the remaining glyphosate.[280] This observation may indicate rapid metabolism of free glyphosate, followed by slower degradation of the less-available, soil-bound glyphosate. The degradation rate is generally correlated with the microbial activity of soils, with microbes degrading glyphosate faster under aerobic conditions and at higher temperatures. Recent work in Denmark indicates that degradation rates correlate most strongly with the population size of *Pseudomonas* spp.bacteria in the soil.[281]

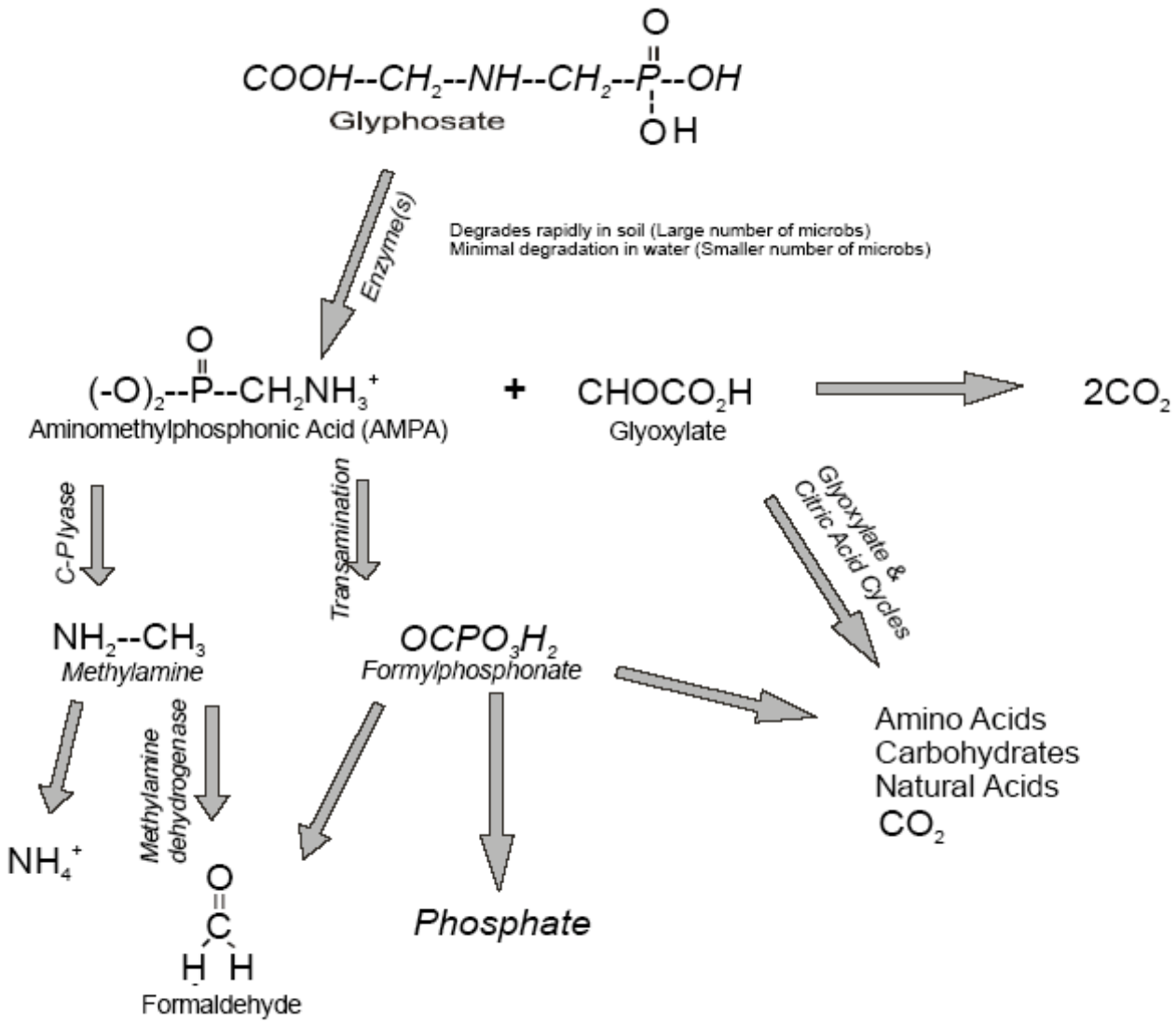



**Figure 3-2:** Degradation pathways of glyphosate, excerpted from Reference 253.

### *3.4.3.B Transport by Air*

Air transport of glyphosate away from the application site can occur through spray drift during and for a short time after an application. Spray drift can contaminate soil and surface waters, damage non-target plants, and expose humans and wildlife through inhalation and dermal exposure. In areas where glyphosate is heavily used, such as in the growing of Roundup-Ready™ crops, glyphosate is routinely detected in air and rainwater.

A recent study of glyphosate and AMPA levels in air and rain in the Midwest showed glyphosate in 60-100 percent of samples at concentrations as high as 9.1 ng/m$^3$ in air and 2.5 µg/L in rainwater.[282] The highest concentrations observed in the study corresponded to intense periods of glyphosate applications. The authors determined that both spray drift and soil erosion contribute to the occurrence of glyphosate and AMPA in the air. Post-application volatilization drift is not a significant source of off-site transport for glyphosate and its salts or AMPA because of their low

vapor pressures (< 7 x $10^{-9}$ mm Hg at 25° C). When dissolved in water, glyphosate does not appreciably escape to the air, as indicated by its very low Henry's law constant of <1.44 x $10^{-12}$ atm-$m^3$/mol.

#### *3.4.3.C Transport by Water*

In most agricultural settings, glyphosate does not leach more than six inches into soils. EPA concludes that glyphosate does not typically reach groundwater.[6] Laboratory experiments show that <0.1–11 percent of the applied herbicidal activity (glyphosate not bound to soil) is recovered when water is leached through soil columns under conditions simulating an extremely high rainfall.[10] Other work indicates that there are conditions under which substantial leaching of glyphosate to groundwater can still occur—when soil quality is poor, containing a high percentage of gravel and a low organic matter,[283] or in the presence of fractured soils with preferential pathways that can transport runoff to groundwater.[284]

Surface waters may become contaminated when glyphosate-containing herbicides are applied over or near waterways, or during heavy rains when chemicals could runoff into lakes, streams and reservoirs.[285] Factors affecting the amount of glyphosate in runoff are rainfall intensity, soil composition, slope characteristics and vegetation cover.[255] Dissipation of glyphosate in surface waters is fairly rapid and occurs through dilution, downstream transport, or sorption to sediments.[286]

In a Danish study, concentrations of glyphosate in groundwater underlying agricultural application sites with subsurface tile drains were measured between <0.1 and 4.7 µg/L.[284] Pesticides with strong soil-sorbing characteristics are generally not expected to contaminate groundwater, but preferential transport to groundwater can occur through flow pathways such as sand, gravel or soil fractures. This type of transport is enhanced by high post-application rainfall intensities on saturated soils and/or by structural characteristics that provide flow channels into groundwater.[254]

The discovery of glyphosate in field drain water in Denmark above the country's limit for all chemical contaminants of 0.1 µg/L led to a ban in 2003 of its use on certain clay soils in the fall rainy season. This ban was overturned in 2004 after glyphosate product manufacturers Monsanto, Cheminova and Syngenta objected that the finding of glyphosate and AMPA in subsurface drains did not equate to the presence of glyphosate in the deeper groundwater used for drinking water.[287] After additional study, the Danish EPA agreed and revoked the ban on autumn uses in December 2004, stating:

> *" . . . the Danish Environmental Protection Agency believes that no unacceptable risk of pollution of the groundwater is associated with the currently approved agricultural use of glyphosate. the Agency thus does not consider that the updated state of our knowledge provides any technical grounds for the imposition of restrictions on the autumn application of glyphosate."* (translated from the Danish by Monsanto[287b])

The frequency of glyphosate detections in surface water and observed concentrations are a function of several interrelated factors, including timing and location of sampling relative to pesticide application, hydrology, and water transport pathways. From a study of three

agricultural basins in the Midwest and one in France, Coupe *et al.*[288] determined that 0.012–2% of the applied glyphosate was transported to surface waters in these basins. This 200-fold variation underscores the importance of the profoundly different, site-specific factors that determine the proportion of applied glyphosate that is transported to surface waters. The highest transport rates were observed for the Mississippi basin where glyphosate applications and precipitation occurred throughout the growing season and the amount of glyphosate applied per acre was relatively high. The lowest transport rates were observed in France, where the application rates were substantially lower. Concentrations of glyphosate in the French samples were much higher however, because of the low volume of water passing through the basin.

#### *3.4.3.D Uptake by Plants*

Plants treated with glyphosate absorb the chemical though foliage or cut stems of a plant; root systems play a relatively minor role. Surfactants increase the rate of uptake of glyphosate from foliage and stems. Glyphosate is not metabolized by plants, but is translocated to all parts of the plant through the phloem and may accumulate in roots and nodules and eventually be released to the rhizosphere.[289]

#### *3.4.3.E Field Studies on the Environmental Fate of Glyphosate*

We evaluated several recent, large-scale monitoring studies to obtain an estimate of the potential for actual off-site transport under field conditions. Glyphosate and its primary degradation product AMPA were monitored in the Midwest US, Argentina, and Canada. Observed concentrations were below drinking water quality standards (US) and water quality criteria (Canada) in the relatively flat landscapes and agricultural soils of the Midwest and Canada. Higher concentrations were observed in the Argentina study.

In 2002, the USGS measured the concentrations of glyphosate, AMPA and several other herbicides in runoff from 51 Midwestern streams at three times during the growing season: 1) after the application of pre-emergence herbicides, May-June, 2) after the application of post-emergence herbicides, June-July, and 3) during harvest season, September-November.[290] Thirty-one to 40 percent of the samples contained glyphosate over the method reporting limit of 0.0001 mg/L. The highest concentration detected was 0.009 mg/L measured during harvest season—well below the US EPA Maximum Contaminant Level (MCL) set for drinking water of 0.7 mg/L and the California Public Health Goal of 0.9 mg/L.[11] Most samples were in the range of 0.1–1.0 μg/L. AMPA was detected in 53–83% of samples, with a high concentration of 1.3 μg/L and most samples in the range of 0.0001–0.0005 mg/L. In spite of the fact that estimated use of glyphosate (50 million lbs) exceeded that of atrazine (42 million lbs) in the Midwest in 2002, observed glyphosate concentrations were substantially lower than those of atrazine. [290]

In 2009, USGS looked specifically at glyphosate concentrations in vernal pools used by amphibians for breeding in National Parks near application sites for invasive vegetation management projects, using foliar and cut-stump application methods.[291] The authors found that the frequency of detections of glyphosate in water after applications was 87%, with the highest concentrations observed in areas near cut-stump sites. The maximum observed concentration of 0.328 mg/L of glyphosate is well above the 0.040 mg/L level of concern US EPA has set for aquatic endangered species.

In 2003, the USGS also sampled the Leary Weber Ditch Basin in the Midwest.[292] Leary Weber Ditch is a small, intermittent stream that drains 2.79 square miles. It is primarily a sub-surface, tile-drain-fed creek, and most of the basin is surrounded by farmland.[293] Agriculture is the main land use in the Leary Weber Ditch Basin, with 87 percent of the total land area used for row crops, including soybeans (47 percent) and corn (39 percent), with some pasture and small grains. In 2003 when monitoring was conducted, an estimated 26,500 lb of glyphosate were applied to 22,600 acres in the Sugar Creek Basin that contains the Leary Weber Ditch Basin, averaging slightly more than one pound per acre. Approximately 97 percent of all soybeans were treated with glyphosate.

The USGS found glyphosate in 34 percent of the 117 ground water samples analyzed, with a maximum concentration of 0.0047 mg/L. The degradation product AMPA was found in 73 percent of groundwater samples, with a maximum concentration of 0.0026 mg/L. Glyphosate was detected more frequently and at higher concentrations in surface waters, with 84 percent of the 64 samples having positive detections and a maximum concentration of 0.427 mg/L in overland flow, a concentration higher than U.S. EPA's 0.040 mg/L level of concern for acute toxicity to endangered species. AMPA was detected in 81 percent of the samples, with a maximum concentration of 0.029 mg/L. The highest concentrations were observed in overland flow during the first storm after the application. A second set of samples collected during the second storm after the application showed a marked decrease in concentrations in overland flow by approximately a factor of 10. Lower concentrations were observed where the overland flow was diluted by stream flow.

In an Argentinian study, the authors evaluated glyphosate runoff in an area of intensive soybean cultivation.[294] Concentrations of glyphosate were higher than those observed in the USGS study, ranging from 0.100 to 0.700 mg/L, with the highest concentrations observed immediately adjacent to the treated field. Concentrations were typically three to five times lower 1.5 kilometers downstream of the application site.

Environment Canada monitored glyphosate in the surface waters of an agricultural area in southern Ontario over a 2-year period.[295] Sampling was conducted bi-weekly from April to November, but was not explicitly correlated with runoff events. Twenty-one percent of the samples contained glyphosate at concentrations higher than the method detection limit of 0.005 mg/L and 3.4% were above the method reporting limit of 0.017 mg/L. The highest concentration measured was 0.041 mg/L. None of the samples contained glyphosate at levels greater than 0.065 mg/L, the Canadian Water Quality Guideline for protection of aquatic life.

The USGS and Canadian studies showed low to moderate surface water glyphosate concentrations in regions of very high glyphosate use, while Argentinian studies showed substantially higher surface water glyphosate concentrations. The differences observed between the Midwest US and Canadian studies and the Argentinian study may be a result of the timing of sampling, the closer proximity of the Argentinian site to waterways, differences in terrain and soil types, and the contributions of overspray. The conflicting data indicate how important careful application is to avoiding contamination of nearby waterways.

Region 5 (Pacific Southwest) of the USFS has conducted water quality monitoring after herbicide use in reforestation or invasive plant management in the Eldorado, Stanislaus, Sierra, and Angeles National Forests between 1991 and 1999.[296] Glyphosate was monitored in eight of these studies, both immediately after application to detect any spray drift into waterways and during the first runoff event, typically 60–90 days after the application. A buffer zone of at least 10 feet between streams and waterways was utilized in all but one case, where spraying was actually conducted in the waterway for *Arundo donax.* Out of 104 total water and sediment samples taken for the eight projects, only two detections of glyphosate were noted—88 µg/kg in sediment (this result was attributed by USFS to either contamination of the sample or private land contribution) and 15 µg/L for one sample from the *Arundo donax* treatment area.

### 3.4.4 Aquamaster Product Profile

The Aquamaster™ product has been selected as one of the herbicides to be considered by UCSF for possible use in its vegetation management plan. Aquamaster™ (US EPA reg # 524-343) contains the isopropylamine (IPA) salt of glyphosate as the active ingredient (a.i.) at 53.8 weight percent, with the remaining 46.2 percent made up with water.[297] It is approved for direct application to water bodies. The product contains 648 g/L (5.4 lb/gal) of the isopropylamine (IPA) salt of glyphosate, which is equivalent to 480 g/L (4 lb/gal) of the acid equivalent (a.e.) of glyphosate.[298] When applied as a foliar spray, Aquamaster is typically mixed at 0.5–8.0% a.i. in aqueous solution with a surfactant added to aid penetration of the a.i. through the waxy cuticle of the plant surface. For cut-stump/stem applications, solutions ranging from 5-100 percent of the product are used. The maximum application rate of Aquamaster, or “label rate”, including all glyphosate-based products is two gallons per acre per year, which equates to eight pounds of glyphosate acid per acre per year. Mount Sutro application rates would be 4 lb/acre or less. The label also recommends a nonionic surfactant at no more than one quart per acre.

EPA has given this product an acute hazard warning label of CAUTION, placing it in Category IV.[299] This rating means that it is considered to be “Practically non-toxic.” Exposure to skin or eyes may cause skin irritation and eye irritation.[300]

### 3.4.5 Known Impurities

Technical grade glyphosate contains an impurity, N-nitrosoglyphosate (NNG). Specific information on nitrosamine concentrations in glyphosate formulations have been submitted to US EPA, but are not available for public review.[301] However, the US EPA has determined that 92% of technical grade glyphosate contains NNG at less than one part per million (<1 mg/L) and concludes that this amount is toxicologically insignificant.[5]

The POEA surfactant used in Roundup, another glyphosate-containing product, contains 1,4-dioxane as an impurity, a compound that is rated as a **Probable** Human Carcinogen by the US EPA. The upper limit of this compound in Roundup is about 0.03%.[5] However, because UCSF has selected Aquamaster as the glyphosate-containing herbicide product, this impurity is not relevant to this risk assessment.

## *3.5 Exposure Assessment and Risk Characterization for Glyphosate*

Assessment of risk requires knowledge of both the inherent toxicity of a chemical and the amount of exposure that is anticipated based on intended uses. Risk characterization combines the hazard and exposure data to provide a picture of risks associated with herbicide use.

This risk characterization is presented for Demonstration Projects 1 and 4 and for the Main Project, each of which is described in the Notice of Preparation / Initial Study and summarized in Section 2.1.[302] Each section below reports differences, if any, in exposure and risk for the Demonstration Projects in comparison to the Main Project. As discussed in Section 2.1, doses are calculated on a per-acre basis in many cases. These per-acre dose values typically do not differ when comparing the full project to the demonstration projects, with limited exceptions discussed individually below.

This exposure analysis is divided into four categories: workers, general public, terrestrial wildlife, and aquatic life, each assessing potential exposures from either cut stump or directed foliar treatment methods. Potential application rates considered are listed in Table 3-12. The maximum allowable application rate—sometimes called the “label rate”—for glyphosate acid equivalent (a.e.) is eight pounds per acre per year, which is equivalent to eight quarts of Aquamaster per acre per year.[298] The maximum application rate for the Mount Sutro project is four pounds of glyphosate acid equivalent per year.

This risk assessment assumes compliance with the application guidelines and treatment schedule described in Section 2.5.1. The results described below are based on the maximum application rate under consideration for the Mount Sutro project, four pounds of glyphosate per acre on all of the 48 accessible acres in the reserve, which is designated as the Maximum Treatment scenario. The risks from this scenario and alternate treatment scenarios are summarized in the tables and charts in Sections 3.5.4 and 3.5.5 below. In total, the risks associated with four different scenarios were estimated:

1) Maximum treatment scenario: All accessible acres (48 total) treated at the maximum application rate of 4 lb a.e./acre;

2) Half-treatment scenario: Half the accessible acres (24 acres) treated at the maximum application rate or all of the acres treated at 2 lb a.e./acre; and
3) Quarter-treatment scenario: One-quarter of the accessible acres (12 acres) treated at the maximum application rate or all of the acres treated at 1 lb a.e./acre.
4) Demonstration project scenario: Demonstration Project area #4 treated at the maximum application rate of 4 lb a.e./acre.

With minor changes described in Section 2.5, the worksheets created by the Syracuse Environmental Research Associates (SERA) for the US Forest Service were used to calculate estimated glyphosate exposures and risks for workers, the general public, and terrestrial and aquatic wildlife.[303] Water contamination scenarios for accidental spills, peak runoff and long-term runoff into Woodland Creek; accidental spills into puddles/pools; and short-term runoff into San Francisco Bay and the Pacific Ocean were also evaluated (see Section 3.5.3 below). The details of how the exposures were calculated are discussed in Section 2.5.

Exposure scenarios were categorized as "**Highly Probable**," "**Probable**," "**Possible**," "**Improbable**" and "**Highly Improbable**.**"** These five categories are used throughout the exposure estimates to designate the qualitative likelihood of each scenario occurring. Common scenarios and their probabilities are summarized in Tables 2-9 through 2-12 of Chapter 2. The probabilities assigned in those tables are based on the assumption that the application guidelines are followed.

For all of the different exposure scenarios, **Lower**, **Central** and **Upper** estimates were calculated for a given application rate. Central estimates were obtained using parameter values that are perceived as most realistic. Upper exposure estimates were calculated by changing all parameters to values that increase estimates, and Lower estimates were obtained by changing all parameters to values that decrease estimates, except for direct spray and accidental worker scenarios (see Section 2.5.3.A). The Central estimate is the best estimate of the most likely exposure. The Lower and Upper estimates provide a lower bound and a worst-case scenario that is less likely—and usually much less likely—than the Central estimate. More information about the types of exposure scenarios considered in this risk assessment is available in Section 2.5. Toxicity reference values (TRVs) used in the analysis for glyphosate are discussed in Section 3.2.1.I (humans) and Section 3.3 (animals and other organisms).

**Hazard Quotients (HQs):** Exposure estimates for humans and wildlife are divided by human reference doses (RfDs) and wildlife toxicity reference values (TRVs) to give hazard quotients (HQs) that provide an estimate of risk from different exposure scenarios. (RfDs differ from TRVs by inclusion of uncertainty factors to account for inter- and intra-species variation.) Hazard quotients above 1.0 indicate that exposure exceeds the level of concern, and humans or wildlife may be at risk of adverse effects. These scenarios are flagged as potentially problematic and recommendations are made for how to avoid them. Hazard quotients between 0.1 and 1.0 suggest that particularly sensitive individuals or species may be affected. Hazard quotients below 0.1 indicate low levels of risk for the effects that have been studied and represented by the TRVs. In this document, hazard quotients less than 1.0 are reported as a percent of the TRV; HQs greater than 1.0 are reported as a multiplier of the TRV, e.g. "the HQ was 2.4 times the TRV."

**Inerts and surfactants:** There are no added "inert" ingredients in Aquamaster, with the only ingredients being glyphosate and water. However, Aquamaster is usually mixed with a surfactant prior to use. The toxicity of mixtures of glyphosate with Competitor, the surfactant being considered for use by UCSF, is not fully known, but is anticipated to be much lower than that of glyphosate mixed with the POEA surfactant that is part of most Roundup™ product mixtures. See Chapter 5 for more discussion of surfactants.

### 3.5.1 Chemical-Specific Exposure Parameters for Glyphosate

Many of the parameters used to estimate exposure are constant from chemical to chemical, e.g., typical amounts of food consumed, surface area of a child and body weight, among others. These parameters and the values used in the exposure models are discussed in Section 2.5. Other parameters are chemical-specific—absorption coefficients and water contamination rates, for example—and are based on experimental data and/or physical properties such as water solubility, $K_{ow}$, vapor pressure, $K_{oc}$ and half-life.

Table 3-11 presents the glyphosate-specific parameters used in the calculations, including dermal absorption rates, and glyphosate water contamination rates. The parameters described in Table 3-11 would be equivalent for the Demonstration Projects and the Main Project because they are simply properties specific to glyphosate. As discussed in Section 2.5.3.A, USFS/SERA developed an estimate of dermal absorption rates based on $K_{ow}$ and molecular weight.[304] These values were compared to studies of glyphosate absorption through the skin of monkeys, human cadavers[305a, b] and human volunteers.[306] Calculated dermal absorption was within a factor of four of the empirically measured rates. Given the agreement between the estimates and the empirical values, it would make little difference which absorption rates were used. The empirical values from the human cadaver studies were used in the USFS worksheets. Glyphosate runoff rates are discussed in more detail in Section 3.5.3 on Water Contamination Estimates below. The parameters described in Table 3-11 would be equivalent for the Demonstration Projects and the Main Project because they are simply properties specific to glyphosate.

**Table 3-11: Glyphosate-Specific Exposure Parameters**

| Parameter | Lower Value | Central Value | Upper Value |
|---|---|---|---|
| $K_a$, First-order dermal absorption rate ($h^{-1}$) | 0.00013 | 0.00041 | 0.001 |
| $K_p$, Dermal permeability (cm/hr) | $1.5x10^{-7}$ | $3.7x10^{-7}$ | $6.3x10^{-5}$ |
| Water contamination rate (mg/L per lb/acre), acute | 0.0013 | 0.011 | 0.083 |
| Water contamination rate (mg/L per lb/acre), chronic | 0.00001 | 0.0001 | 0.0058 |
| Half-life as residue in soil (days) | 30 | 45 | 60 |

*Data source:* USFS, 2010. Reference 303. Half-lives were adapted from a local Marin County study, Reference 279.

Glyphosate is proposed for use on Mount Sutro for directed foliar and/or cut-stump treatments at a maximum rate of 4 lb/acre. The application rates and volumes listed in Table 3-12 were used to calculate Lower, Central and Upper exposure estimates for workers, the general public, and terrestrial and aquatic wildlife. These estimates were calculated for the four treatment scenarios: Maximum treatment, Half-treatment, Quarter-treatment and Demonstration projects. The cut-stump application scenarios assume concentrations of herbicide 5–10 times higher for the Central, Lower and Upper estimates than the assumed concentrations for foliar application because higher concentrations are typical for cut-stump treatment. See Section 2.1 for a

discussion of application rates and concentrations commonly used for glyphosate-based herbicides.

**Table 3-12: Application Rate and Application Volume Model Inputs for Aquamaster**

| Scenario | Parameter | Lower | Central | Upper |
|---|---|---|---|---|
| Foliar application | Application rate (lb a.e./acre) | 1 | 2 | 4 |
| | Percent active ingredient (by volume) | 1% | 2% | 5% |
| | Application volume[a] (gallons/acre) | 20 | 50 | 100 |
| Cut-stump treatments | Application rate (lb a.e./acre) | 1 | 2 | 4 |
| | Percent active ingredient (by volume) | 5% | 20% | 50% |
| | Application volume[a] (gallons/acre) | 2 | 5 | 20 |

[a] Application volume represents total volume of product plus diluent. Reference 303, Worksheet A01.

### 3.5.2 Application Methods for Glyphosate

Application methods for glyphosate that may be used for understory vegetation and trees on Mount Sutro include directed (spot) foliar or cut stump/cut stem treatments. See Section 2.1.1 and 2.1.2 for a discussion of cut stump treatments. Cut-stump application involves cutting the stem, and then spraying or painting Aquamaster at 5–50 percent of the pure product on the cut stump surface.

### 3.5.3 Water Contamination Estimates

Concentration estimates for several water contamination scenarios were calculated for glyphosate: accidental spill scenarios to puddles/pools and Woodland Creek, peak runoff and long-term runoff scenarios for Woodland Creek, and a short-term runoff scenario for the San Francisco Wastewater Treatment Plants (WWTPs). The spill scenarios typically include two spill volumes (one and 20 gallons) each for a spill of the more-dilute, foliar solutions and the more-concentrated, cut stump solutions, with Central, Lower and Upper estimates based on the varying concentrations of the solutions. See Section 2.5.2 for a detailed discussion of these scenarios. Results are shown in Table 3-13 below. The values in Table 3-13 are not equivalent for Demonstration Project 1 (South Ridge Area) compared to the Main Project because Demonstration Project 1 does not drain to Woodland Creek, but rather toward Christopher Drive to the southwest, where it is intercepted by the city stormwater system and carried to San Francisco's Oceanside Treatment Plant. Demonstration Project 4 (East Bowl Corridor) does drain to Woodland Creek; scenarios built for any treatment that drains to Woodland Creek will apply equally to Demonstration Project 4.

Throughout this document, the word "contaminated" is used to mean that any amount of a chemical residue is present. "Contaminated" does not necessarily equate to hazardous, but indicates only that the compound is present at some level.

A method for predicting water contamination rates in mg/L per pound of herbicide applied per acre for glyphosate runoff during a storm (peak runoff) and over the longer-term (long-term runoff) was derived by USFS/SERA using GLEAMS modeling (see Section 2.5.2). The USFS model validated their results with data from empirical studies in which glyphosate was applied adjacent to, or directly over, water bodies in a location where rain is frequent[307a-d] The highest

value observed for water contamination rates based on monitoring data was 0.28 mg/L per pound of glyphosate applied for over-water applications.[307c] The lower range of values from the monitoring data evaluated by USFS is 0.003 to 0.007 mg/L per pound applied.[307d]

Recent work by the US Geological Survey (USGS) indicates that fairly high concentrations of glyphosate can occur locally in runoff, particularly in water flowing over treated areas ("overland flow"); however, concentrations are substantially lower once diluted by stream flow. For example, in the 22,600-acre Sugar Creek basin in Indiana,[288] where 26,500 pounds of glyphosate was applied (equivalent to an application rate of 1.17 lb/acre), concentrations of glyphosate in overland flow were measured between 0.0215 and 0.430 mg/L. During the same time frame, measured concentrations in Sugar Creek, a large-volume stream, ranged from 0.00015 to 0.0016 mg/L, equivalent to 0.00013–0.0014 mg/L per pound per acre. Concentrations in the Leary Weber Ditch, a smaller volume stream (approximately 10–100 cfs) that drains a 1,020-acre area treated with 1,240 pounds of glyphosate (equivalent to an application rate of 1.21 lb/acre) were nearly identical to those in Sugar Creek, ranging from 0.00016 to 0.0021 mg/L and equivalent to 0.00013–0.0017 mg/L per pound per acre. In another USGS study, local concentrations as high as 0.328 mg/L were measured in a pond two days after the first rainfall a week after herbicide treatment.[291]

The topography of Mount Sutro ensures that stream flow will continue to dilute any herbicide washed off of treated areas; however, the available monitoring data suggests that local overland flow may wash glyphosate into puddles or pools on site, possibly resulting in concentrations above levels of concern. We did not model this scenario because we lacked the data to do so, but note that concentrations will be higher in overland flow than in Woodland Creek. Risks to animals drinking out of puddles and to aquatic species using puddles for breeding habitat could be reduced by filling in ruts or depressions near treatment sites.

In estimating herbicide concentrations in Woodland Creek due to runoff, we used the USFS/SERA water contamination rates for the peak runoff scenario of 0.0013 to 0.083 mg/L per lb/acre for Lower and Upper scenarios, respectively, with a Central value of 0.011 mg/L. The calculations for long-term runoff scenarios were adjusted for degradation of glyphosate over time. Starting with the chronic USFS water contamination rates ranging from 0.00001 to 0.0058 mg/L per lb/acre, the chemical half-life in soil (see Table 3-11) was used to calculate a fraction of the chemical degraded during the 0–120 day window before the rainy season begins. See Section 2.5.2 for a detailed discussion of the methods used to estimate water contamination rates used in the USFS/SERA worksheets.

### Table 3-13: Calculated Glyphosate Concentrations for Water Contamination Scenarios

| Scenario | Concentration (mg/L) Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|
| **Cut-Stump Treatment** (Concentrations at right) | **20%** | **5%** | **50%** | |
| Accidental spill into a 5-100 Liter puddle/pool | | | | |
| 1 gal | 7,255 | 907 | 181,377 | HI / HI |
| Accidental spill into Woodland Creek, flowing at 2-10% of peak flow | | | | |
| 1 gal | 427 | 53 | 2,667 | HI / HI |
| 20 gal | 8,535 | 1,067 | 53,346 | HI / HI |
| **Foliar Treatment** (Concentrations at right) | **2%** | **1%** | **5%** | |
| Accidental spill into a 5-100 Liter puddle/pool | | | | |
| 1 gal | 725 | 181 | 18,138 | HI / HI |
| Accidental spill into Woodland Creek, flowing at 2-10% of peak flow | | | | |
| 1 gal | 43 | 11 | 267 | HI / HI |
| 20 gal | 853 | 213 | 5,335 | HI / HI |
| **Rainfall Runoff** | **Central** | **Lower** | **Upper** | |
| **Maximum Treatment Scenario[1]** | | | | |
| Peak runoff into Woodland Creek | 0.044 | 0.0052 | 0.33 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | 0.0003 | 0.00003 | 0.023 | **Pr / Pr** |
| **Half-Treatment Scenario[2]** | | | | |
| Peak runoff into Woodland Creek | 0.022 | 0.0026 | 0.17 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | 0.0002 | 0.00001 | 0.012 | **Pr / Pr** |
| **Quarter-Treatment Scenario[3]** | | | | |
| Peak runoff into Woodland Creek | 0.011 | 0.0013 | 0.083 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | 0.0001 | 0.00001 | 0.0058 | **Pr / Pr** |
| **Demonstration Project #4[4]** | | | | |
| Peak runoff into Woodland Creek | 0.012 | 0.0015 | 0.094 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | 0.0001 | 0.00001 | 0.0066 | **Pr / Pr** |

Scenario Probabilities: DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable.

[1] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[2] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[3] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[4] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

Predicted water contamination rates for glyphosate runoff to the Oceanside and Southeast WWTPs were estimated for the four treatment scenarios using USFS/SERA herbicide runoff rates from GLEAMS modeling. Runoff varies depending on climate and soil type, and the USFS/SERA method provides a range of scenarios to choose from. We used the scenario that most closely describes the Mount Sutro environment.

According to the 2001 Mount Sutro Open Space Management Plan, sandy loam soils predominate on the Reserve:[308]

> *In general, soils on Mount Sutro are thin, sandy material. The soil complex is mapped as Candlestick fine sandy loam—Kron sandy loam—Buriburi gravelly loam, on 30 to 75% slopes (SCS 1991). The constituent soil types of this complex are likely to occupy different areas. The Candlestick fine sandy loams are usually from 20 to 40 inches thick over bedrock, whereas the Buriburi gravelly loam and the Kron sandy loam are usually from 10 to 40 inches thick over bedrock. Many slopes have less than six inches of soil depth.*

Because San Francisco's climate is dry and temperate from approximately May through September and wet and cool during the rainy season from October through April, estimated glyphosate loss from runoff as a fraction of the application rate is presented in Table 3-14 for these two different site conditions and loam soils. Table 3-14 serves as only a rough estimate of runoff rates for Mount Sutro. The USFS/SERA worksheets (and hence the water contamination rates for the exposure estimates) do not incorporate site-specific characteristics such as the distance between the treatment site and the water body, the total number of acres treated, the volume of the receiving water bodies and the slope; instead, the calculations were based on a standard parameter set (described in Section 2.5.2.B and explicitly listed in Table 13, p. 295 in USFS 2011[5]). These values are very similar to the equivalent parameter "loading as a percentage of use" (LAPU) of 0.012–2.0 percent calculated for glyphosate by the USGS from a wide variety of studies in different agricultural settings.[288]

For homes that border the Reserve, the probability of herbicide-contaminated runoff entering private property is very low because, for most of the watersheds on Mount Sutro (see Appendix B for a map of watersheds), rainfall runoff from the reserve is intercepted by roadside drainage culverts and routed to storm drains. Runoff from Watersheds Two and Four is the only runoff not captured by a storm drain. Watershed Two borders the back yards of 9-10 homes along the north end of Edgewood Avenue; however, as noted in the Application Guidelines in Section 2.5.1, herbicides would not be applied within 100 feet of the backyards along Edgewood Avenue or Christopher and Crestmont Streets. This 100-foot buffer zone extends beyond the western edge of Watershed Two, so no herbicides will be applied within this watershed at all, eliminating the possibility of herbicide transport to private property in this location. Watershed Four borders the Interior Greenbelt, owned by the City of San Francisco. Approximately two acres of this watershed are proposed for treatment with herbicides, which would result in an equivalent amount of herbicide in runoff as for Demonstration Project 4, which is two acres as well. Herbicide concentrations in runoff to private property bordering the Interior Greenbelt are anticipated to be substantially lower after the runoff has traversed the Interior Greenbelt property, with herbicides adsorbing to soil and leaf litter as they flow across the land. Ensuring

that Watershed Four is treated early in the summer to provide as much time as possible for herbicide degradation to occur would reduce runoff further. An experiment conducted in Marin County to determine the fate of glyphosate used in vegetation management projects found that runoff from the treated sites contained no measureable quantities of glyphosate or AMPA, an observation the authors attributed to the deep layer of plant litter in the treated areas and the strong adsorption of glyphosate to the litter and soil.[279] Similar conditions prevail on Mount Sutro, which suggests that glyphosate transport to private property will be very low.

**Table 3-14: Percent of Glyphosate Lost as a Function of Annual Rainfall and Soil Type**

| Site Conditions | Percent of Herbicide Lost on Loam Soils | | |
|---|---|---|---|
| | Lower | Central | Upper |
| Dry and temperate | 0 | 0 | 0 |
| Wet and cool | 0.165 | 0.58 | 2.28 |

*Data source:* Table 1 in Appendix 10 to USFS Glyphosate Risk Assessment.[309]

Table 3-15 presents modeled estimates of herbicide concentrations at wastewater treatment plants, averaged over 24 hours of runoff. These concentrations are based on the number of acres treated, glyphosate runoff rate estimates from Table 3-14, and wet-weather capacities at San Francisco's Oceanside and Southeast wastewater treatment plants (see Section 2.5.2.H for a detailed discussion of the method of calculation). The four scenarios described above are modeled: Maximum treatment, Half-treatment, Quarter-treatment, and Demonstration plots. In addition, an estimated concentration of herbicide at Southeast WWTP was calculated should a 20-gallon spill to Woodland Creek occur.

**Demonstration Projects and Herbicide Concentration at Wastewater Treatment Plants**: As Table 3-15 shows, treating Demonstration Projects 1 and 4 would result in lower herbicide concentrations at the WWTPs than treating a larger number of acres as part of the main project. Because herbicide concentrations in runoff are proportional to acres treated, even treating the largest (two-acre) Demonstration Project, #4, would result in lower herbicide concentrations at WWTPs than the Main Project. The Upper estimates of herbicide concentration due to treatment at Demonstration Project 1 and 4 are 0.000025 and 0.000020 mg a.e./L, respectively.

**Table 3-15: Glyphosate Concentrations at Wastewater Treatment Plants During the 5-Year Storm**

| Scenario | Acres Treated per Year at 4 lb/acre[1] | Max Lbs Glyphosate Applied Per Year[1] | WWTP In-plant Capacity (MGD) | Glyphosate Concentration (mg/L) | | |
|---|---|---|---|---|---|---|
| | | | | Central | Lower | Upper |
| **Glyphosate Runoff Rate[2]** (at right) | | | | 0.58% | 0.17% | 2.28% |
| **Maximum Treatment Scenario[3]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[7] | 38.7 | 154.6 | 43 | 0.0003 | 0.0001 | 0.0010 |
| East Side watersheds (Southeast WWTP)[7] | 9.3 | 37.4 | 110 | 0.00002 | 0.00001 | 0.00009 |
| **Half-Treatment Scenario[4]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[7] | 19.3 | 77.3 | 43 | 0.0001 | 0.00004 | 0.0005 |
| East Side watersheds (Southeast WWTP)[7] | 4.7 | 18.7 | 110 | 0.00001 | 0.000003 | 0.00005 |
| **Quarter-Treatment Scenario[5]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[7] | 9.7 | 38.7 | 43 | 0.00006 | 0.00002 | 0.0002 |
| East Side watersheds (Southeast WWTP)[7] | 2.3 | 9.3 | 110 | 0.000006 | 0.000002 | 0.00002 |
| **Demonstration Projects 1 and 4[6]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[7] | 1 | 4 | 43 | 0.000006 | 0.000002 | 0.00003 |
| East Side watersheds (Southeast WWTP)[7] | 2 | 8 | 110 | 0.000005 | 0.000001 | 0.00002 |
| **Accidental 20-Gallon Spill into Woodland Creek** | | | | | | |
| East Bowl Corridor (DP 4, Southeast WWTP) | NA | 80 | 110 | 0.0087 | 0.0087 | 0.0087 |

MGD = million gallons per day

[1] Acres treated and maximum pounds applied are per year were determined by the application guidelines and the treatment schedule. See Section 2.5.1.B for complete details.

[2] Glyphosate runoff rate is the percent of applied glyphosate that runs off of a treated area. Estimates are based on USFS GLEAMS modeling.

[3] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre."

[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre."

[6] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

[7] West side watersheds, which flow to Oceanside WWTP, are those numbered 1, 6, and 8–13 in Appendix B; East side watersheds, which flow to Southeast WWTP, are those numbered 2–5 and 7 in Appendix B.

## 3.5.4 Risks to Humans

Human exposure estimates were performed for both workers and members of the general public. For herbicide applicators ("workers"), accidental/incidental and general handling exposures were considered for cut-stump applications. General public exposure estimates were developed for the scenarios of people sitting on treated stumps or contacting treated vegetation, direct sprays, a woman or child drinking contaminated water, and herbicide runoff to private property. Acute and chronic exposure scenarios were evaluated to obtain a range of exposure estimates for worst-case ("Upper"), more probable ("Central") and best-case ("Lower") exposure scenarios.

### *3.5.4.A Workers*

Risks from accidental and general exposure scenarios were calculated for herbicide applicators. Accidental exposures include wearing contaminated gloves for one minute and one hour, spill

onto hands, and spill onto lower legs. General exposures per day were calculated as a function of pounds per acre of herbicide applied, hours worked per day and acres treated per hour. The estimated accidental doses are much lower than for general exposures, according to USFS, because glyphosate is not readily absorbed dermally, and because the accidental dermal exposures are shorter (one minute to one hour) than general exposures that accumulate over the course of a workday.[310] Confidence in these exposure assessments is reasonably high because of the availability of dermal absorption data in humans as well as worker exposure studies. Doses and hazard quotients for all worker exposure scenarios can be found in Table 3-16 and Figure 3-3 below.

The risk characterizations for cut-stump and foliar workers suggest that careful workers would be at minimal risk of exceeding the RfD. Precautions should be taken to avoid spills to unprotected skin and eyes, including the use of goggles, gloves, long-sleeved clothing and closed shoes. Applicators should have extra gloves, soap and water for washing off spills, and an eyewash bottle in their vehicle at all times.

At the maximum four pounds per acre of glyphosate acid, only one worker exposure scenario exceeded 10% of the RfD: the Upper estimate of general worker exposure for foliar spray workers, with an HQ of 0.16, or 16 percent of the RfD for humans. For cut-stump workers, the Upper HQ for general exposure was 0.095, or 9.5 percent of RfD for humans. No Central or Lower estimates exceeded a Hazard Quotient of 0.10.

Both the cut-stump and foliar general handling exposure scenarios are considered **Highly Probable** because they represent exposure as a result of typical working environments using standard personal protective equipment. However, Upper and Lower exposure estimates are inherently less likely than Central estimates because they model extreme values for every parameter. For general handling exposure, the Upper estimate assumes maximum hours worked per day (8 hrs), maximum acres treated per hour (1 acre/hr) and maximum dermal absorption (0.01 mg of herbicide absorbed per kg of body weight per pound handled per day). General exposure estimates were calculated using the assumption that a spray applicator would be used for treating cut stumps; however, if only a brush or wick applicator were used, risks could be reduced substantially, by approximately a factor of 10, based on the biomonitoring study by Lavy *et al.* (see Section 3.2.3).[68]

**Highest Exposures:** The highest exposure estimate for the **Improbable** (spill) scenarios was an accidental spill to a worker's lower legs during a cut stump application, left unwashed for one hour. This would result in an estimated Upper exposure of 0.023 mg/kg, which is approximately 1.2 percent of the RfD for humans. The risk estimates are the same for the Main Project and the Demonstration Projects on a per-workday basis; however, since the Demonstration Project areas take less time to treat, the overall risks are lower for work on the Demonstration Projects. Doses and hazard quotients for all worker exposure scenarios can be found in Table 3-16. This scenario is considered **Improbable** and is independent of application rate, since exposure is calculated on a per-event basis.

**Most Likely Exposures:** Exposure estimates from the scenarios that are most likely to occur for workers are highlighted below:

1. **General exposure for cut-stump workers (Highly Probable)**. The Central dose estimates Central exposure estimates from the normal handling of herbicide required for conducting cut-stump treatments with a spray applicator are 2.5 percent of the RfD for cut-stump applicators. Upper and Lower estimates are 9.5 percent and 0.35 percent of the RfD, respectively.

2. **General exposure for foliar spray workers (Highly Probable)**. The Central dose estimate for general foliar spraying exposure is 2.6 percent of the RfD. The Upper estimate, as stated above, is the highest estimated worker exposure at 16 percent of the RfD.

3. **Wearing contaminated gloves for one minute (Probable)**. The Upper dose estimate for wearing contaminated gloves for one minute is 0.004 percent of the RfD for cut stump applicators working with glyphosate at 50 percent concentration. Central estimates and estimates for foliar concentrations are substantially lower.

Aggregate doses from multiple accidental worker exposures can be obtained by adding the dose received from each scenario to the general exposure. For example, if a worker applies herbicide to cut stumps for eight hours and also wears a contaminated glove for one hour, the combined Upper exposure estimate is 0.19 + 0.004 mg per kg body weight per day. For glyphosate, the general exposure estimates are so much higher than the accidental exposures (roughly by a factor of ten in the example above) that aggregate exposures are not significantly different from general exposure. A worker would have to spill chemical on his or her hands ten times and leave it there for an hour before he or she would achieve an Upper estimated dose equivalent to a day of general exposure from applying herbicide.

These exposure estimates do not include splashes into the eyes, as there are no quantitative exposure estimates for this situation. Glyphosate and glyphosate formulations are mild to moderate skin and eye irritants,[297] but little systemic absorption would be expected from such an event.

### Table 3-16: Estimated Risks for Workers from Glyphosate Exposures

| Scenario | Duration | Dose | | | RfD | Hazard Quotients | | | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | (mg/kg-day) | Central | Lower | Upper | |
| **Accidental Exposures for Applicators (mg/kg body weight/event)** | | | | | | | | | |
| Cut-stump concentrations (5%, 20% and 50%) | | | | | | | | | |
| Contaminated Gloves | 1 min | 3E-05 | 7E-06 | 7E-05 | 2 | 1E-05 | 4E-06 | 4E-05 | **Pr / Pr** |
| | 1 hr | 0.0017 | 0.0004 | 0.0043 | 2 | 0.0009 | 0.0002 | 0.0022 | I / I |
| Spill on hands | 1 hr | 0.0038 | 0.0009 | 0.0094 | 2 | 0.0019 | 0.0005 | 0.0047 | I / I |
| Spill on lower legs | 1 hr | 0.0093 | 0.0023 | 0.023 | 2 | 0.0046 | 0.0012 | 0.012 | I / I |
| Foliar spray concentrations (1%, 2%, and 5%) | | | | | | | | | |
| Contaminated Gloves | 1 min | 3E-06 | 1E-06 | 7E-06 | 2 | 1E-06 | 7E-07 | 4E-06 | **Pr / Pr** |
| | 1 hr | 0.0002 | 9E-05 | 0.0004 | 2 | 9E-05 | 4E-05 | 2E-04 | I / I |
| Spill on hands | 1 hr | 0.0004 | 2E-04 | 0.0009 | 2 | 0.0002 | 9E-05 | 0.0005 | I / I |
| Spill on lower legs | 1 hr | 0.0009 | 5E-04 | 0.0023 | 2 | 0.0005 | 0.0002 | 0.0012 | I / I |
| **General Handling Exposure for Applicators (mg/kg body weight/day) based on 6-8 hrs worked** | | | | | | | | | |
| **Four pounds per acre applied** | | | | | | | | | |
| Cut-stump Worker | 6-8 hrs | 0.050 | 0.0071 | 0.19 | 2 | 0.025 | 0.0035 | 0.095 | **HP / HP** |
| Backpack Foliar Worker | 6-8 hrs | 0.053 | 0.0018 | 0.32 | 2 | 0.026 | 0.0009 | 0.16 | **HP / HP** |
| **Two pounds per acre applied** | | | | | | | | | |
| Cut-stump Worker | 6-8 hrs | 0.025 | 0.0035 | 0.095 | 2 | 0.012 | 0.0018 | 0.047 | **HP / HP** |
| Backpack Foliar Worker | 6-8 hrs | 0.026 | 0.0009 | 0.16 | 2 | 0.013 | 0.0005 | 0.080 | **HP / HP** |
| **One pound per acre applied** | | | | | | | | | |
| Cut-stump Worker | 6-8 hrs | 0.012 | 0.0018 | 0.047 | 2 | 0.0062 | 0.0009 | 0.024 | **HP / HP** |
| Backpack Foliar Worker | 6-8 hrs | 0.013 | 0.0005 | 0.080 | 2 | 0.0066 | 0.0002 | 0.040 | **HP / HP** |

RfD = Reference dose. Hazard Quotients above 0.1 are shaded. Hazard Quotients greater than one are shaded and **bolded.**
DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

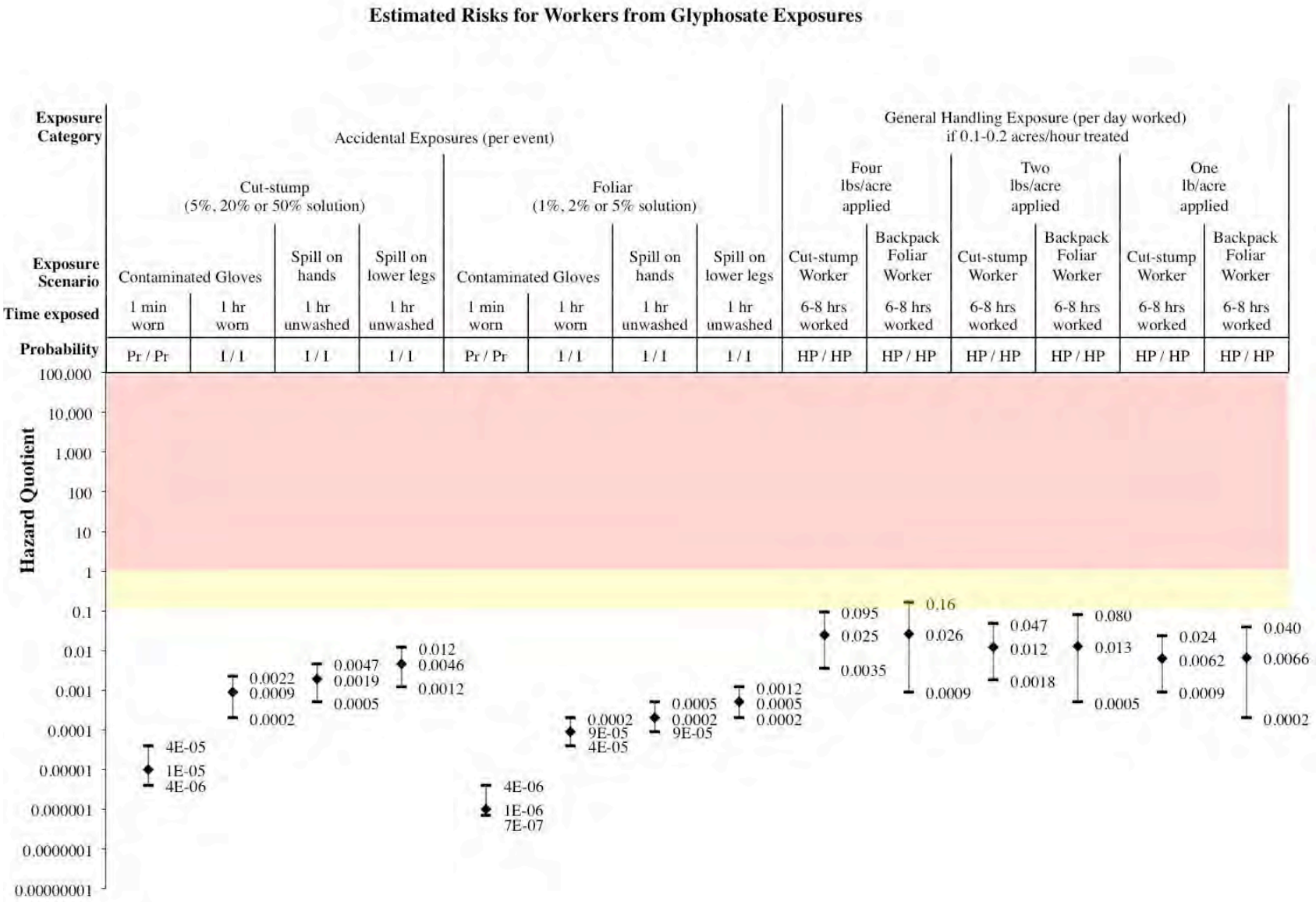



**Figure 3-3**: Estimated risk of glyphosate exposures for workers. See Table 3-16 above for data used to create this chart and definitions of terminology and abbreviations used.

### *3.5.4.B General Public*

Acute and chronic glyphosate exposure scenarios for the general public were evaluated for direct spray to a child's body or woman's legs, contact with contaminated vegetation or treated stump surfaces. The risks associated with dermal exposure scenarios for the general public are summarized in Table 3-17 and Figure 3-4.

Consumption of contaminated water was evaluated for an adult female and a child who may drink out of a small puddle or pool after a spill or out of a pool in Woodland Creek after a spill or during peak or long-term runoff under the different treatment scenarios (Maximum, Half, Quarter and Demonstration Project). The highest exposures of all scenarios resulted from the **Highly Improbable** case of a child drinking out of Woodland Creek or out of a puddle or pond after a spill of herbicide into those water bodies. These scenarios would be highly problematic should they occur and every precaution should be taken to avoid these scenarios. The risks associated with contaminated water exposure scenarios for the general public are summarized in Table 3-18 and Figure 3-5. Contamination of drinking water reservoirs from runoff of glyphosate in the watershed is not considered because no reservoirs are so located as to potentially intercept herbicide runoff from Mount Sutro; Laguna Honda Reservoir to the southwest of Mount Sutro is separated from the project area by city streets which will route runoff to city stormwater systems. (Runoff to wastewater treatment plants is considered in Section 3.5.3 above.)

For homes that border the reserve, the probability of herbicide-contaminated runoff entering private property is very low and does not exceed levels of concern for the highly improbable scenario of humans drinking contaminated water from runoff.

**Most Likely Exposures:** Table 2-10 in Chapter 2 summarizes the probabilities assumed for each scenario. The most likely scenarios for exposure of the general public to glyphosate are a woman or child sitting on a treated stump or brushing against contaminated vegetation. These scenarios would not pose a risk of exposure near the level of the Reference Dose of 2 mg per kg body weight since the highest exposure from these scenarios was estimated at just 0.55 percent of the RfD. Three exposures were considered to be **Possible** for the general public:

1. **A woman wearing shorts sitting on a treated stump for one hour** (**Possible** for Main Project; **Improbable** for Demonstration projects).
   The Upper estimated dose for this scenario is 0.32 percent of the RfD. The Central estimate is 0.040 percent of the RfD. These estimates are well below levels of concern.
2. **A child wearing shorts sitting on a treated stump for one hour** (**Possible** for Main Project; **Improbable** for Demonstration projects).
   The Upper estimated dose for this scenario is 0.55 percent of the RfD. The Central estimate is 0.069 percent of the RfD. These estimates are well below levels of concern.
3. **Brushing against contaminated vegetation** (**Possible** for Main Project; **Improbable** for Demonstration projects).
   The Upper estimated dose for this scenario is 1.9 percent of the RfD. The Central estimate is 0.50 percent of the RfD. These estimates are the highest among **Probable** or **Possible** exposures to the general public, but still well below levels of concern.

**Highest Exposures:** It is also useful to consider the scenarios that yield the highest exposures, regardless of their probability, to evaluate the potential need for additional precautions to protect the public. For glyphosate, the following scenarios exceeded an HQ of one for Lower, Central, and Upper estimates:

1. **A child drinking out of Woodland Creek after a spill of one or 20 gallons of product at cut-stump or foliar concentrations.** (**Highly Improbable** for Main Project and Demonstration Projects)
   This scenario would lead to exposures from 24 percent of the RfD to thousands of times the RfD, depending on the size of spill and concentration of herbicide spilled. The lowest estimated dose (Lower estimate for a one gallon, foliar-concentration spill) is 24 percent of the RfD, but all other HQs are greater than one. Central estimated doses for a one gallon or twenty gallon spill are 16 times and 321 times the RfD, respectively. The Upper estimate for a 20-gallon spill is over 3,000 times the RfD.
2. **A child drinking out of a puddle or pond after a spill of one gallon of product at cut-stump or foliar concentrations**. (**Highly Improbable** for Main Project and Demonstration Projects)
   This scenario would lead to exposures at least four times and up to thousands of times the RfD, depending on the size of spill and concentration of herbicide spilled. The lowest estimated dose (Lower estimate for foliar-concentration spill) is 4.2 times the RfD. Central estimated doses are 27 times the RfD for a foliar-concentration spill and 273 times the RfD for a cut-stump concentration spill. The Upper estimate for a 20-gallon spill is over 10,000 times the RfD.

The 20-gallon spills scenarios are considered **Highly Improbable** for both the Main Project and Demonstration Projects. The one-gallon spill scenarios are considered **Improbable** for the Main Project and **Highly Improbable** for the Demonstration Projects.

Contamination of Woodland Creek by long-term runoff is considered **Probable** for the Main Project if the entire 7.08 acres of the Woodland Creek watershed is treated in a single year and **Probable** for the Demonstration Project #4, in which only two of the 7.08 acres are treated in a given year. The Central estimated dose for an adult female drinking water contaminated from long-term runoff is just 0.0005 percent of the RfD; this Central estimate assumes that 40 percent of herbicide applied has already decayed over a period of 60 days. The Upper estimate, which assumes no herbicide decay, is 0.04 percent of the RfD, higher but still several orders of magnitude below the RfD.

### Table 3-17: Estimated Risks for the General Public from Glyphosate Accidental Acute Dermal Exposures

| Scenario | Receptor | Dose (mg/kg per event) | | | RfD | Hazard Quotients | | | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | (mg/kg-day) | Central | Lower | Upper | |
| **Cut-stump Treatment Solution (5%, 20% or 50%)** | | | | | | | | | |
| Direct spray of child, whole body | Child | 0.14 | 0.036 | 0.36 | 2 | 0.071 | 0.018 | 0.18 | HI / HI |
| Direct spray of woman, feet and lower legs | Adult Female | 0.014 | 0.004 | 0.036 | 2 | 0.0072 | 0.0018 | 0.018 | HI / HI |
| Cut-stump contact, sitting, shorts | Adult Female | 0.0008 | 0.0001 | 0.0064 | 2 | 0.0004 | 0.00006 | 0.003 | I / **Po** |
| Cut-stump contact, sitting, shorts | Child | 0.0014 | 0.0002 | 0.011 | 2 | 0.0007 | 0.0001 | 0.0055 | I / **Po** |
| **Foliar Treatment Solution (1%, 2% or 5%)** | | | | | | | | | |
| Direct spray of child, whole body | Child | 0.014 | 0.007 | 0.036 | 2 | 0.007 | 0.004 | 0.018 | HI / HI |
| Direct spray of woman, feet and lower legs | Adult Female | 0.0014 | 0.0007 | 0.0036 | 2 | 0.001 | 0.0004 | 0.002 | HI / HI |
| Vegetation contact, 1 hour, shorts and T-shirt 4 lb a.e./acre applied | Adult Female | 0.010 | 0.0015 | 0.037 | 2 | 0.0050 | 0.0007 | 0.019 | I / **Po** |
| Vegetation contact, 1 hour, shorts and T-shirt 2 lb a.e./acre applied | Adult Female | 0.0050 | 0.00074 | 0.019 | 2 | 0.0025 | 0.0004 | 0.0094 | I / **Po** |
| Vegetation contact, 1 hour, shorts and T-shirt 1 lb a.e./acre applied | Adult Female | 0.0025 | 0.0004 | 0.0094 | 2 | 0.0012 | 0.0002 | 0.0047 | I / **Po** |

RfD = Reference Dose. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable
Hazard Quotients above 0.1 are shaded. Hazard Quotients greater than one are shaded and **bolded.**

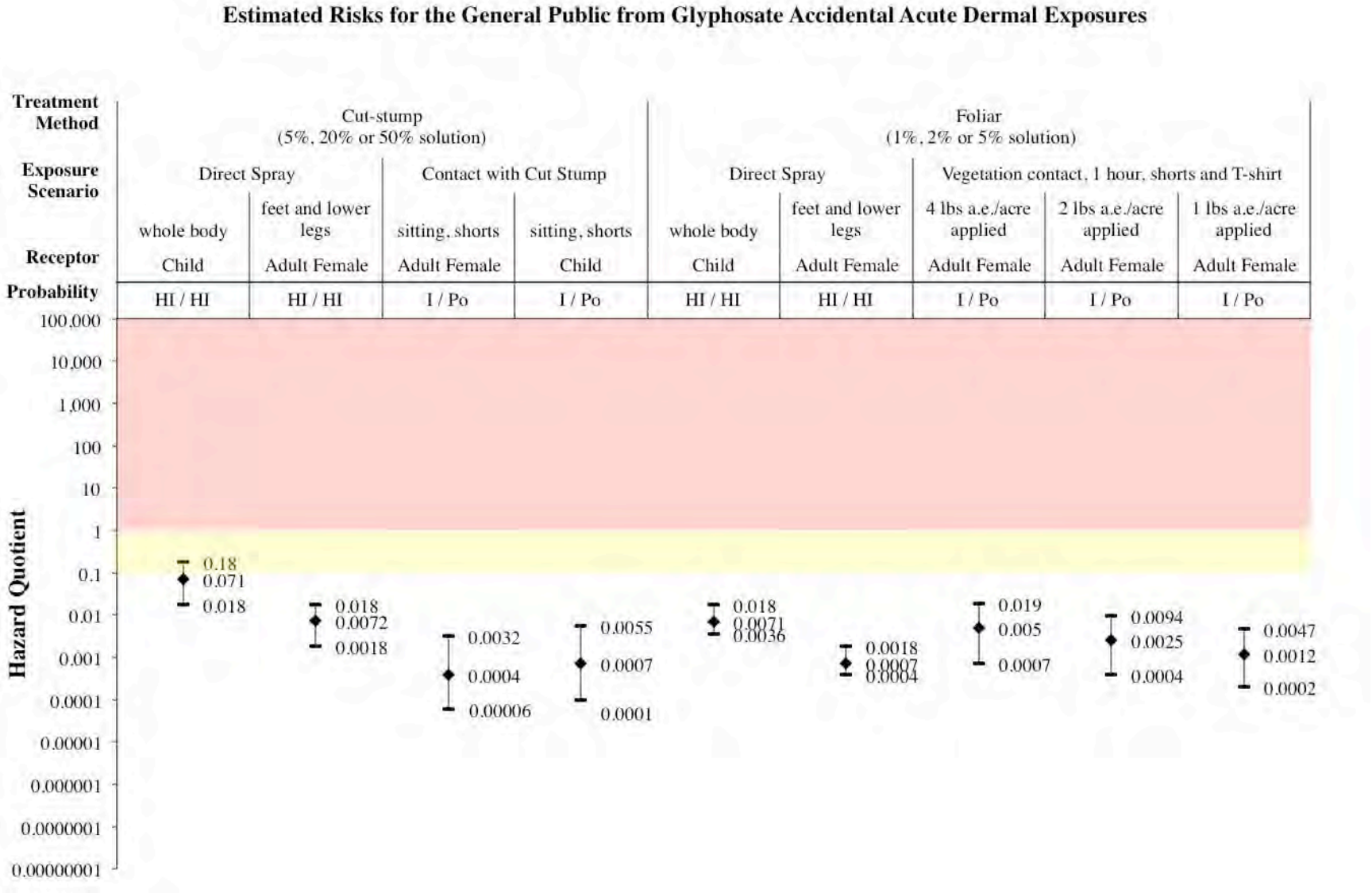



**Figure 3-4**: Estimated risks for accidental acute dermal contact with glyphosate-treated surfaces for the General Public. See Table 3-17 above for data used to create this chart and definitions of terminology and abbreviations used.

**Table 3-18: Estimated Risks for Humans Drinking Glyphosate-Contaminated Water**

| Scenario | Receptor | Dose (mg/kg body weight/event) | | | RfD | Hazard Quotients | | | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | (mg/kg-day) | Central | Lower | Upper | |
| **Spill to a 5-100 L Puddle/Pool of One-Gallon of Herbicide** | | | | | | | | | |
| Foliar Concentrations (1%, 2% and 5%) | Child | 55 | 8.3 | 2,046 | 2 | **27** | **4.2** | **1,023** | HI / HI |
| Cut-Stump Concentrations (5%, 20% and 50%) | Child | 545 | 42 | 20,456 | 2 | **273** | **21** | **10228** | HI / HI |
| **Spill to Woodland Creek of 1-20 Gallons of Herbicide** | | | | | | | | | |
| Foliar Concentrations (1%, 2% and 5%) | | | | | | | | | |
| 1 gallon | Child | 3.2 | 0.49 | 30 | 2 | **1.6** | 0.24 | **15** | HI / HI |
| 20 gallons | Child | 64 | 9.8 | 602 | 2 | **32** | **4.9** | **301** | HI / HI |
| Cut-Stump Concentrations (5%, 20% and 50%) | | | | | | | | | |
| 1 gallon | Child | 32 | 2.4 | 301 | 2 | **16** | **1.2** | **150** | HI / HI |
| 20 gallons | Child | 642 | 49 | 6,016 | 2 | **321** | **24** | **3008** | HI / HI |
| **Herbicide Runoff into Woodland Creek** | | | | | | | | | |
| Maximum Treatment Scenario[1] | | | | | | | | | |
| Peak runoff | Child | 0.0033 | 0.0002 | 0.037 | 2 | 0.0017 | 0.00012 | 0.019 | HI / HI |
| Long-term runoff | Adult Female | 1E-05 | 5E-07 | 0.0009 | 2 | 5E-06 | 3E-07 | 0.0004 | HI / HI |
| Half-Treatment Scenario[2] | | | | | | | | | |
| Peak runoff | Child | 0.0017 | 0.0001 | 0.019 | 2 | 0.0008 | 0.00006 | 0.009 | HI / HI |
| Long-term runoff | Adult Female | 5E-06 | 3E-07 | 0.0004 | 2 | 2E-06 | 1E-07 | 0.0002 | HI / HI |
| Quarter-Treatment Scenario[3] | | | | | | | | | |
| Peak runoff | Child | 0.0008 | 0.0001 | 0.0094 | 2 | 0.0004 | 0.00003 | 0.0047 | HI / HI |
| Long-term runoff | Adult Female | 2E-06 | 1E-07 | 0.0002 | 2 | 1E-06 | 7E-08 | 0.0001 | HI / HI |
| Demonstration Project #4[4] | | | | | | | | | |
| Peak runoff | Child | 0.0009 | 0.00007 | 0.011 | 2 | 0.0005 | 0.00003 | 0.0053 | HI / HI |
| Long-term runoff | Adult Female | 3E-06 | 2E-07 | 0.0002 | 2 | 1E-06 | 8E-08 | 0.0001 | HI / HI |

RfD = Reference Dose. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

[1] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[2] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[3] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[4] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

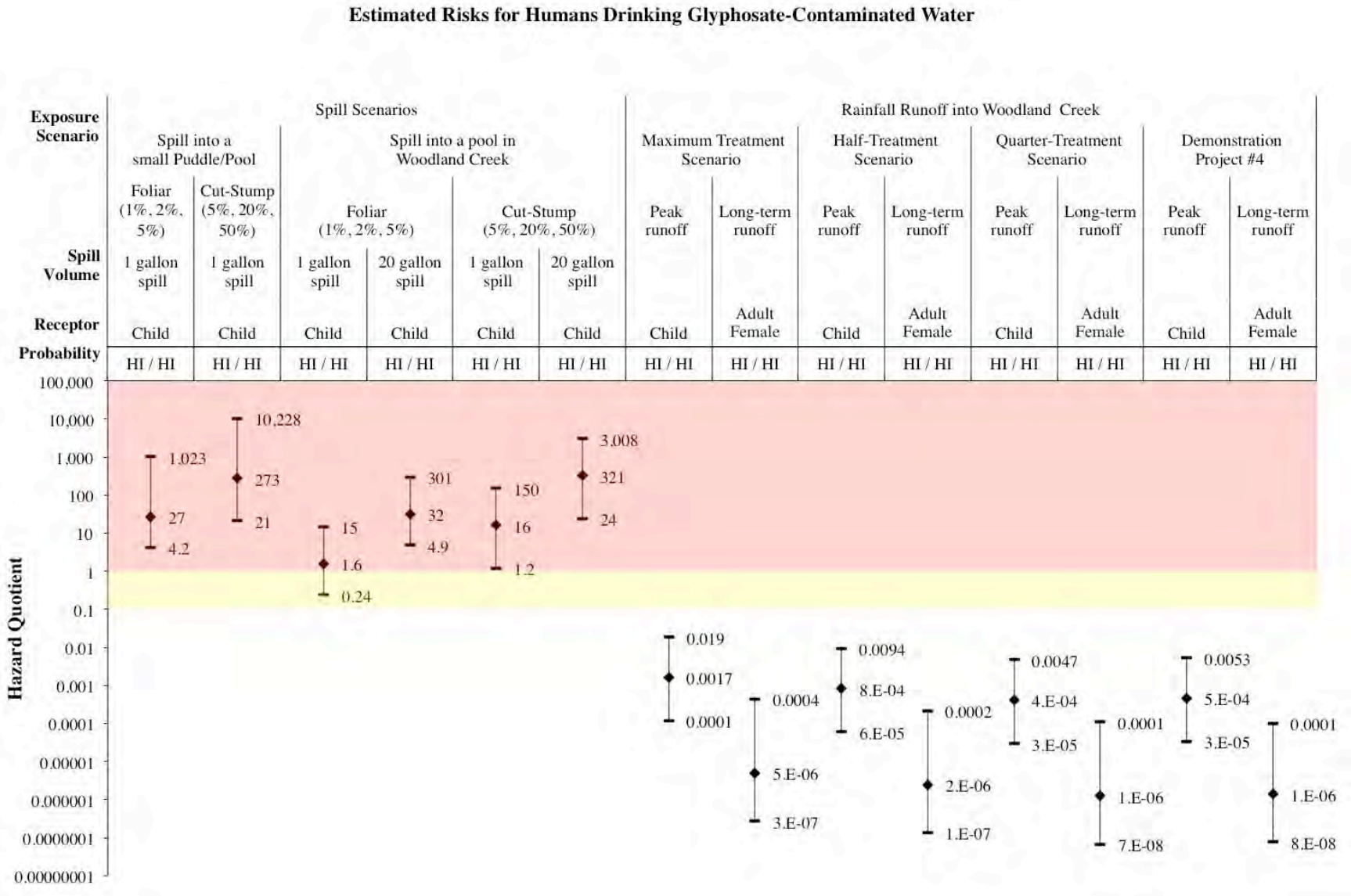



**Figure 3-5**: Estimated risks from acute and chronic consumption of glyphosate-contaminated water by the general public. See Table 3-18 above for data used to create this chart and definitions of terminology and abbreviations used.

### 3.5.5 Risks to Wildlife

The wildlife risk assessment is divided into two parts, terrestrial and aquatic. For terrestrial animals, risks are assessed for dermal, food and drinking water exposures resulting from spills, peak runoff, and long-term runoff to Woodland Creek under Maximum, Half, Quarter and Demonstration plot scenarios. For aquatic wildlife, risks are assessed for spills and peak runoff and long-term runoff to Woodland Creek under Maximum, Half, Quarter and Demonstration plot scenarios, as well as short-term runoff to the Southeast and Oceanside WWTPs. See Section 2.5 for a discussion of the methods used to estimate wildlife exposures.

Aquatic organisms are at much greater risk from glyphosate exposure compared to terrestrial wildlife. For terrestrial wildlife, no **Possible** or **Probable** scenario has HQs greater than 1.0; only the **Improbable** exposures from drinking contaminated water after spills (**Highly Improbable** for Demonstration Projects) exceed HQs of 1.0. For aquatic wildlife, all Upper, Central and Lower estimates of spill scenarios led to HQs greater than one for amphibians and aquatic invertebrates. For aquatic plants, all Upper and Central HQ estimates were greater than one, and only one Lower HQ estimate was less than one—a one gallon spill into Woodland Creek of one percent glyphosate acid—estimated at 88 percent of the TRV. Terrestrial wildlife spill exposure estimates are also significant, with HQs greater than one in every Upper estimate, and for the majority of (more likely) Central estimates. Unlike for aquatic organisms, most of the Lower estimates are below 10 percent of the TRV for terrestrial wildlife, indicating that small spills of low-concentration glyphosate would not necessarily cause a significant exposure to terrestrial wildlife.

The only aquatic scenarios considered **Probable** (**Possible** for Demonstration Projects) are the peak and long-term runoff scenarios. Exposures from these scenarios did not exceed TRVs for glyphosate for any of the species and treatment scenarios in this risk assessment. The highest Upper HQs (for peak runoff into Woodland Creek) ranged from 15 percent of the TRV for amphibians to 12 percent of the TRV for aquatic invertebrates to 2.7 percent of the TRV for aquatic plants.

For homes that border the reserve, the probability of glyphosate-contaminated runoff entering private property is very low and does not exceed levels of concern for the probable scenarios of terrestrial wildlife or household pets drinking contaminated water from runoff and for amphibians or plants on private property.

#### *3.5.5.A Terrestrial Wildlife*

The wildlife scenarios developed in the SERA worksheets are generally representative of the Mount Sutro settings. Table 3-19 and the accompanying Figure 3-6 shows the acute and chronic risk estimates for dermal and food exposures for mammals and birds. Tables 3-20 and 3-21 and Figures 3-7 through 3-10 show risk estimates for drinking contaminated water for mammals and birds, respectively. Section 3.3.2 contains a summary of glyphosate toxicity studies on terrestrial organisms and a discussion of specific TRVs used for wildlife exposure to glyphosate.

The highest HQs for terrestrial wildlife result from drinking contaminated water after spills. All Upper estimates for twelve such scenarios resulted in HQs greater than one. Six of the twelve Central estimates for spills resulted in HQs greater than one as well. All spill scenarios are

considered **Improbable** or **Highly Improbable** (as discussed in Table 2-12). The only other acute terrestrial wildlife scenarios found to have Upper estimates for HQs greater than one for a single exposure was the direct spray of a small mammal with cut-stump concentration herbicide; this Upper exposure estimate was 97 times the TRV. As discussed below, Upper estimates for nine acute scenarios were greater than 10 percent of the relevant TRVs; five of these scenarios are considered **Possible** or **Probable** for the Main Project.

Tables 3-19 through 3-21 summarize the acute and chronic exposure estimates and hazard quotients for terrestrial wildlife exposure scenarios. Unlike human RfDs, wildlife TRVs do not include uncertainty factors; however, TRVs for sensitive species were selected for this risk assessment, which will ensure most species are protected.

**Most likely dermal and ingestion exposures:** Below are the potential terrestrial wildlife exposures considered **Probable** and **Possible** for the Main Project; probabilities for Demonstration Projects are usually lower (as discussed in Table 2-13). None of these scenarios exceed an HQ = 1; one scenario exceeds an HQ of 0.1.

1. **Direct spray of small mammal, assuming first-order absorption (Possible** for the Main Project**; Improbable** for the Demonstration Projects**).**
   The Upper estimated dose is 0.46 percent of the TRV of 500 mg/kg per day.
2. **A small mammal consuming contaminated vegetation or fruit on-site, chronic (Possible** for the Main Project; **Improbable** for the Demonstration Projects).
   The Upper dose estimate for this scenario is 1.3 percent of the TRV and Central dose is 0.15 percent of the TRV.
3. **A small mammal eating contaminated insects, acute (Possible** for the Main Project; **Possible** for the Demonstration Projects).
   The Upper dose estimate for a small mammal eating contaminated insects is 56 percent of the TRV. The Central dose estimate is 5.6 percent of the TRV.
4. **A small bird eating contaminated insects, acute (Possible** for the Main Project; **Possible** for the Demonstration Projects).
   The Upper dose estimate for a small bird eating contaminated insects is 30 percent of the TRV. The Upper estimate is 3.0 percent of the TRV.
5. **Consumption of contaminated prey (a small mammal) by carnivorous mammals or birds, acute (Possible** for the Main Project; **Improbable** for the Demonstration Projects).
   All exposure estimates for carnivorous mammals and birds are less than two percent of the corresponding TRVs. The highest is an Upper estimate for a carnivorous mammal eating a small mammal, at 1.7 percent of the TRV.

**Most likely water consumption exposures:** The most likely water consumption scenarios for terrestrial wildlife are drinking contaminated water after peak and long-term runoff. These are considered **Probable** for the Main Project; **Possible** for the Demonstration Projects.

1. **Drinking water contaminated by peak runoff, acute (Probable** for the Main Project; **Probable** for the Demonstration Projects).

None of the Upper estimates of long-term drinking-from-runoff scenarios exceeds 0.01 percent of any TRV.

2. **Drinking water contaminated by long-term runoff, chronic (Probable** for the Main Project; **Probable** for the Demonstration Projects). Like the peak runoff scenarios, none of the Upper estimates of long-term drinking-from-runoff scenarios exceeds 0.01 percent of any TRV. Long-term runoff estimates account for herbicide decay over time and are estimated for a smaller volume of runoff (a smaller rain storm), so they are lower than peak runoff rates.

**Highest Exposures:** It is also useful to consider the scenarios that yield the highest exposures, regardless of their probability, to evaluate the potential need for additional precautions to protect the public. For glyphosate, the following scenarios exceeded an HQ of one:

1. **Drinking water from a Woodland Creek pool if contaminated by a 20-gallon spill (Improbable** for Main Project or Demonstration Project 4; N/A for Demonstration Project 1, which does not drain to Woodland Creek)
   This scenario produced the highest HQ estimates of any terrestrial wildlife scenarios. Upper estimates for mammals ranged from 18–312 times the TRV. Birds are at somewhat lower risk, ranging from 7.7 percent to 1.9 times the TRV for birds. Central estimates that assume a 10-gallon spill exceeded the TRV for small mammals based on a spill of glyphosate at 2 percent (foliar) solution or 20-percent (cut-stump) solution. Lower estimates (which modeled a one-gallon spill of 1–5 percent herbicide solution) resulted in HQs from 1.6–0.14 percent of the TRV for mammals and 0.03–2.7 percent of the TRV for birds.
2. **Drinking from a puddle or pool contaminated by a one-gallon spill (Improbable** for the Main Project or the Demonstration Projects**)**.
   Drinking from a puddle or pool after a one-gallon spill of cut-stump or foliar treatment solutions of Aquamaster produced Upper Hazard Quotients ranging from 2.3–53 times the TRV for mammals and 0.45–33 times the TRV for birds. Cleanup of a spill to puddles or pools with absorbent material and proper disposal of the contaminated material off-site would mitigate the effects of such spills.
3. **Direct spray of a small mammal, assuming 100 percent absorption (Improbable** for the Main Project and **Highly Improbable** for the Demonstration Projects**)**.
   The most likely (Central) estimate for direct spray of a 20-percent cut-stump solution is 9.7 times the TRV for a small mammal. The Upper estimate results in a dose 97 times the TRV for mammals for a spray with a 50-percent solution of herbicide. Direct spray assuming foliar concentrations approach but do not exceed the level of concern at 19 percent (Central) and 48 percent (Upper) of the TRV, respectively.
4. **Consumption of contaminated grass by a large bird consuming vegetation on-site (Improbable** for the Main Project and Demonstration Projects**)**.
   The most likely (Central) assumption of 30 percent of the diet contaminated results in an estimated dose that is 33 percent of the TRV for birds. The worst-case (Upper) estimate, which assumes 100 percent of the diet is contaminated, results in a dose 3.6 times the TRV.

Upper exposure estimates for eating contaminated fruit, vegetation or prey all assume that 100 percent of the receptor's diet is contaminated, which is an upper-bound assumption that is unlikely and only realistic for individuals that do not stray outside of treated areas. Central and Lower estimates for eating contaminated fruit, vegetation or prey assume more realistic proportions of the diet to be contaminated: 30 percent and 10 percent, respectively. As with all dose estimates, the Central estimate is considered the most likely.

Of the acute scenarios listed above, three are considered **Possible** or **Probable** and approach levels of concern: consumption of contaminated insects by small mammals (Upper HQ=0.56) or small birds (Upper HQ=0.30), and a small mammal consuming contaminated grass (Upper HQ=0.32). The remainder of the single-exposure terrestrial wildlife exposure scenarios resulted in HQs of less than 0.1.

**Highest Chronic Exposures:** Only one Upper hazard quotient exceeded levels of concern (HQ=1) for chronic exposure—the on-site, chronic consumption of contaminated vegetation by large birds (HQ=3.6). The Central HQ exceeded 0.l for this scenario; however, it is considered **Highly Improbable**.

**Table 3-19: Estimated Risks for Terrestrial Wildlife Exposed to Glyphosate through Direct Sprays and Food Consumption**

| Scenario | Receptor | Dose (mg/kg body weight/event) | | | TRV | Hazard Quotients | | | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | (mg/kg-day) | Central | Lower | Upper | |
| **Accidental Acute Exposures (Direct Spray of 50% of receptor's body surface)** | | | | | | | | | |
| Direct Spray, Foliar Concentrations (1%, 2% and 5%) | | | | | | | | | |
| First-order absorption | Small mammal | 0.95 | 0.30 | 2.3 | 500 | 0.0019 | 0.0006 | 0.0046 | I / **Po** |
| 100% absorption | Small mammal | 97 | 48 | 242 | 500 | 0.19 | 0.097 | 0.48 | HI / I |
| Direct Spray, Cut-Stump Concentrations (5%, 20% and 50%) | | | | | | | | | |
| First-order absorption | Small mammal | 47 | 2.3 | 460 | 500 | 0.095 | 0.0046 | 0.92 | I / **Po** |
| 100% absorption | Small mammal | 4,849 | 242 | 48,488 | 500 | **9.7** | 0.48 | **97** | HI / I |
| **Non-Accidental Acute Exposures** | | | | | | | | | |
| Consumption of Contaminated Vegetation as 10%, 30% or 100% of diet by | | | | | | | | | |
| Fruit | Small mammal | 1.4 | 0.22 | 10 | 500 | 0.0028 | 0.0004 | 0.020 | **Po / Po** |
| Grass | Small mammal | 17 | 2.0 | 161 | 500 | 0.034 | 0.0040 | 0.32 | **Po / Po** |
| Grass | Large bird | 35 | 4.2 | 334 | 1,500 | 0.024 | 0.0028 | 0.22 | I / I |
| Consumption of Contaminated Insects as 10%, 30% or 100% of diet by | | | | | | | | | |
| | Small mammal | 28 | 3.1 | 278 | 500 | 0.056 | 0.0062 | 0.56 | **Po** / **Po** |
| | Small bird | 45 | 5.0 | 452 | 1500 | 0.030 | 0.0034 | 0.30 | **Po** / **Po** |
| Consumption of Contaminated Small Mammal as 10%, 30% or 100% of diet by | | | | | | | | | |
| | Carnivorous mammal | 2.5 | 0.84 | 8.4 | 500 | 0.0050 | 0.0017 | 0.017 | I / **Po** |
| | Carnivorous bird | 3.9 | 1.3 | 13 | 1,500 | 0.0026 | 0.0009 | 0.009 | I / **Po** |
| **Chronic Consumption of Contaminated Vegetation and Fruit as 10%, 30% or 100% of diet** | | | | | | | | | |
| On-site | Small mammal | 0.76 | 0.091 | 6.3 | 500 | 0.0015 | 0.0002 | 0.013 | I / **Po** |
| | Large bird | 19 | 1.8 | 208 | 58 | 0.33 | 0.030 | **3.6** | HI / I |
| Off-site | Small mammal | 0.0033 | 0.0002 | 0.052 | 500 | 7E-06 | 4E-07 | 0.0001 | HI / HI |
| | Large bird | 0.083 | 0.0042 | 1.7 | 58 | 0.0014 | 0.0001 | 0.030 | HI / HI |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

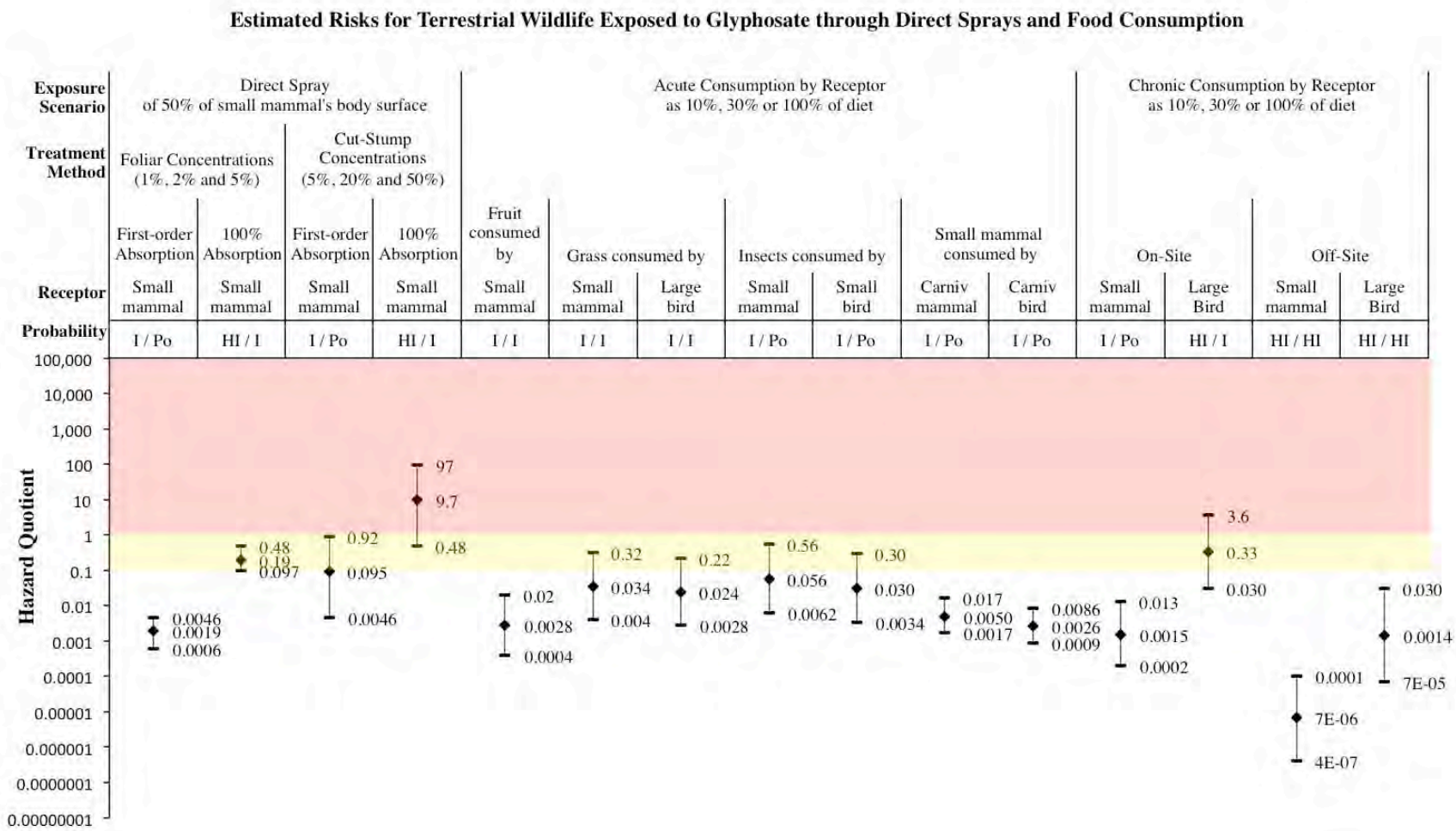



**Figure 3-6**: Estimated risks for terrestrial wildlife exposed to glyphosate through direct sprays and food consumption. See Table 3-19 above for data used to create this chart and definitions of terminology and abbreviations used.

### Table 3-20: Estimated Risks for Mammals Drinking Glyphosate-Contaminated Water

| Scenario | Receptor | Dose (mg/kg body weight/event) | | | TRV | Hazard Quotients | | | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | (mg/kg-day) | Central | Lower | Upper | |
| **Spill to a 5-100 L Puddle/Pool of One Gallon of Herbicide** | | | | | | | | | |
| Cut-Stump Solutions (5%, 20% and 50%) | Small mammal | 1,062 | 133 | 26,553 | 500 | **2.1** | 0.27 | **53** | I / I |
| | Carnivorous mammal | 611 | 76 | 15,287 | 500 | **1.2** | 0.153 | **31** | I / I |
| Foliar Solutions (1%, 2% and 5%) | Small mammal | 106 | 27 | 2,655 | 500 | 0.21 | 0.053 | **5.3** | I / I |
| | Carnivorous mammal | 61 | 15 | 1,529 | 500 | 0.12 | 0.031 | **3.1** | I / I |
| **Spill to Woodland Creek of 1-20 Gallons of Herbicide** | | | | | | | | | |
| Cut-Stump Solutions (5%, 20% and 50%) | Small mammal | 6,248 | 7.8 | 156,195 | 500 | **12** | 0.016 | **312** | I / I |
| | Carnivorous mammal | 3,597 | 4.5 | 89,923 | 500 | **7.2** | 0.0090 | **180** | I / I |
| Foliar Solutions (1%, 2% and 5%) | Small mammal | 625 | 1.6 | 15,619 | 500 | **1.2** | 0.0031 | **31** | I / I |
| | Carnivorous mammal | 360 | 0.90 | 8,992 | 500 | 0.72 | 0.0018 | **18** | I / I |
| **Herbicide Runoff, Maximum Treatment Scenario[1]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small mammal | 0.0064 | 0.0008 | 0.049 | 500 | 0.00001 | 0.000002 | 0.0001 | **Pr / Pr** |
| | Carnivorous mammal | 0.0037 | 0.0004 | 0.028 | 500 | 0.000007 | 0.0000009 | 0.00006 | **Pr / Pr** |
| Long-term runoff[5] | Small Mammal | 0.00005 | 0.000004 | 0.0034 | 500 | 0.00000009 | 0.000000007 | 0.000007 | **Pr / Pr** |
| | Carnivorous mammal | 0.00003 | 0.000002 | 0.0020 | 500 | 0.00000005 | 0.000000004 | 0.000004 | **Pr / Pr** |
| **Herbicide Runoff, Half-Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small mammal | 0.0032 | 0.0004 | 0.024 | 500 | 0.000006 | 0.0000008 | 0.000049 | **Pr / Pr** |
| | Carnivorous mammal | 0.0019 | 0.0002 | 0.014 | 500 | 0.000004 | 0.0000004 | 0.000028 | **Pr / Pr** |
| **Herbicide Runoff, Quarter-Treatment Scenario[3]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small mammal | 0.0016 | 0.0002 | 0.012 | 500 | 0.000003 | 0.0000004 | 0.00002 | **Pr / Pr** |
| | Carnivorous mammal | 0.0009 | 0.0001 | 0.0070 | 500 | 0.000002 | 0.0000002 | 0.00001 | **Pr / Pr** |
| **Herbicide Runoff, Demonstration Project #4[4]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small mammal | 0.0018 | 0.0002 | 0.014 | 500 | 0.000004 | 0.0000004 | 0.00003 | **Pr / Pr** |
| | Carnivorous mammal | 0.0010 | 0.0001 | 0.0079 | 500 | 0.000002 | 0.0000002 | 0.00002 | **Pr / Pr** |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

[1] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.
[2] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[3] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.
[4] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.
[5] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.

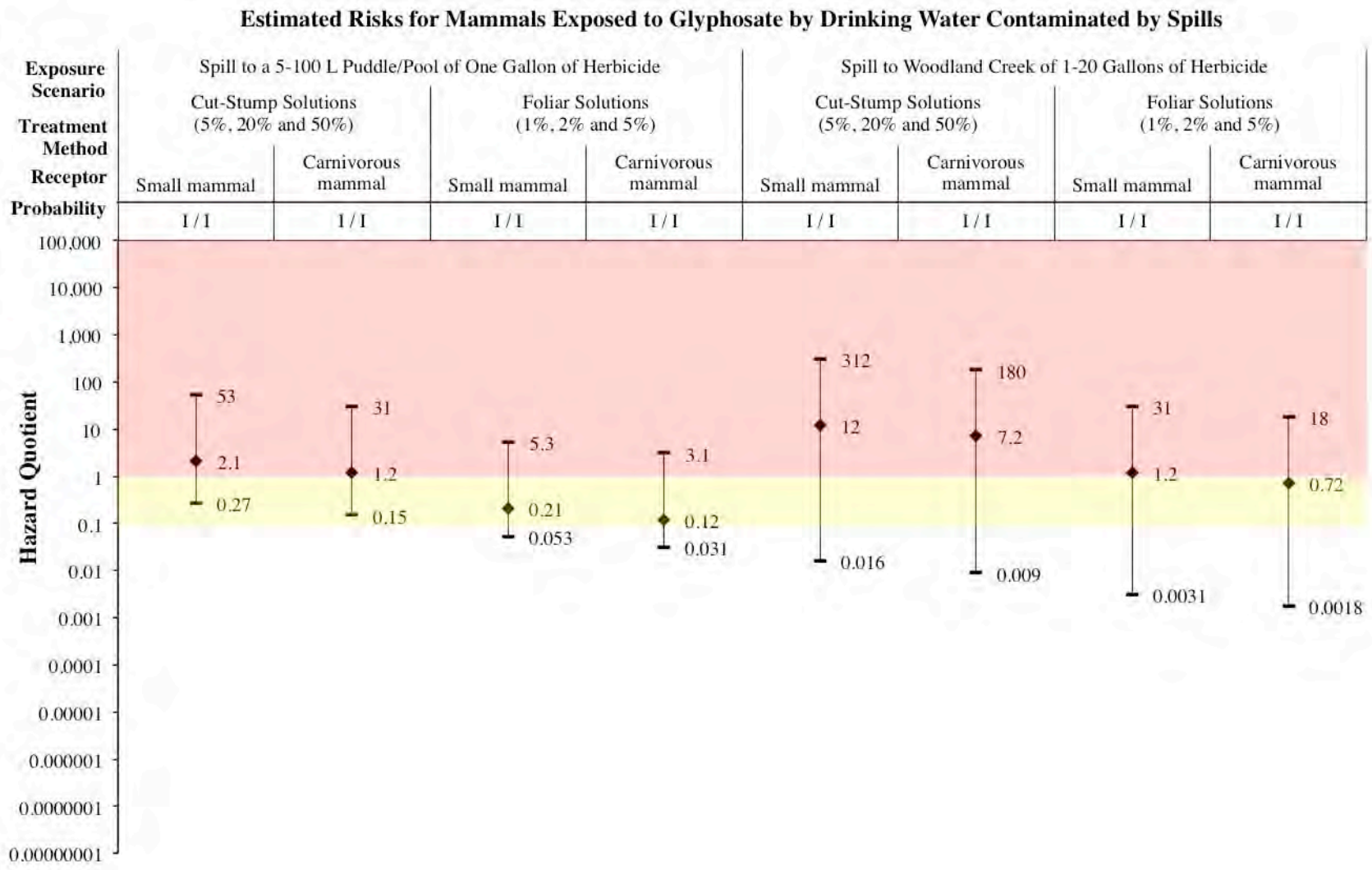



**Figure 3-7**: Estimated risks for mammals exposed to glyphosate by drinking water contaminated by spills. See Table 3-20 above for data used to create this chart and definitions of terminology and abbreviations used.

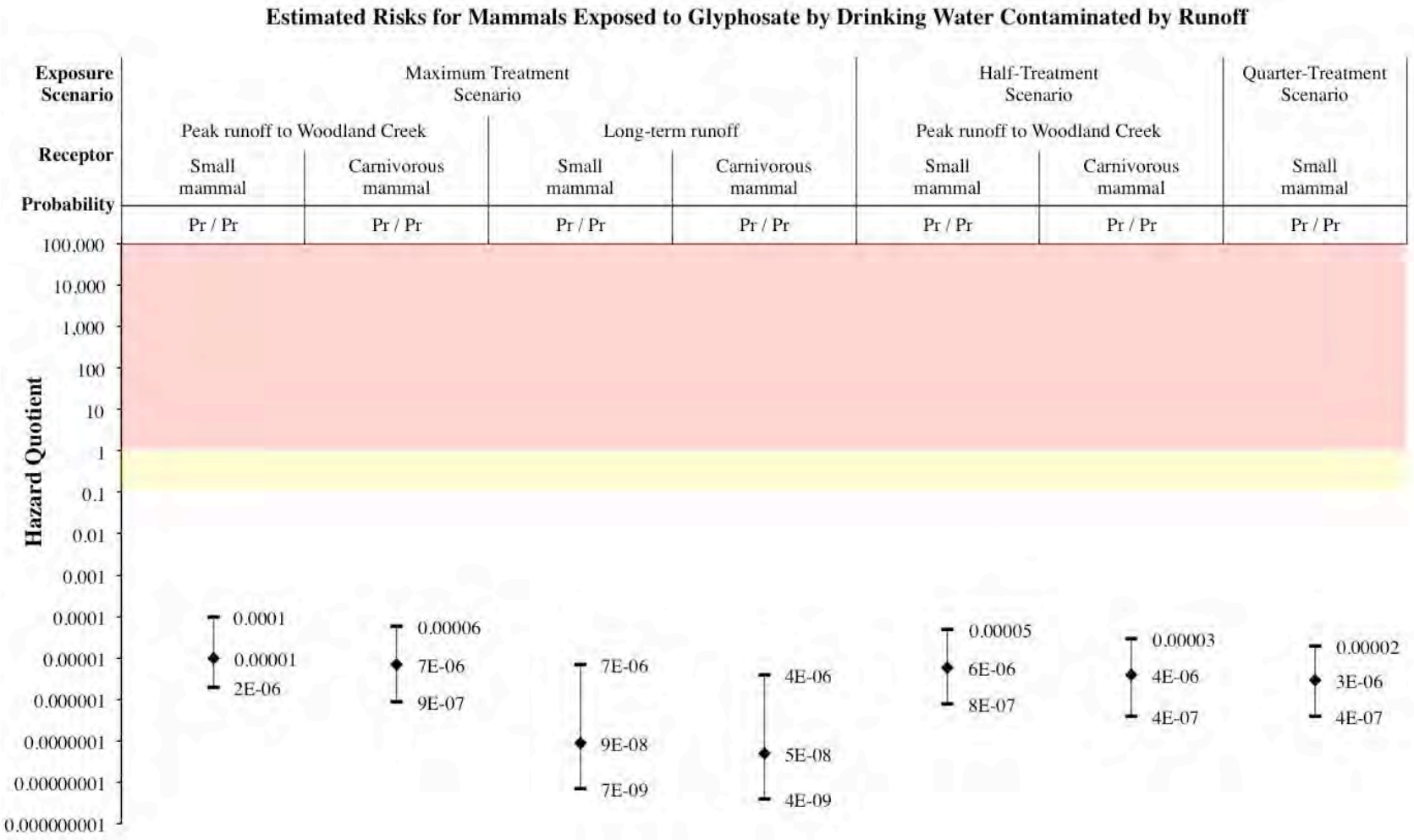



**Figure 3-8**: Estimated risks for mammals exposed to glyphosate by drinking water contaminated by runoff. See Table 3-20 above for data used to create this chart and definitions of terminology and abbreviations used.

### Table 3-21: Estimated Risks for Birds Drinking Glyphosate-Contaminated Water

| Scenario | Receptor | Dose (mg/kg body weight/event) | | | TRV | Hazard Quotients | | | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | (mg/kg-day) | Central | Lower | Upper | |
| **Spill to a 5-100 L Puddle/Pool of One-Gallon of Herbicide** | | | | | | | | | |
| Cut-Stump Treatment Solutions (5%, 20% and 50%) | Small bird | 1,957 | 245 | 48,914 | 1,500 | **1.3** | 0.16 | **33** | I / I |
| | Large bird | 271 | 34 | 6,773 | 1,500 | 0.18 | 0.023 | **4.5** | I / I |
| Foliar Treatment Solutions (1%, 2% and 5%) | Small bird | 196 | 49 | 4,891 | 1,500 | 0.13 | 0.033 | **3.3** | I / I |
| | Large bird | 27 | 6.8 | 677 | 1,500 | 0.018 | 0.0045 | 0.45 | I / I |
| **Spill to Woodland Creek of 1-20 Gallons of Herbicide** | | | | | | | | | |
| Cut-Stump Treatment Solutions (5%, 20% and 50%) | Small bird | 115 | 14 | 2877 | 1,500 | 0.077 | 0.010 | **1.9** | I / I |
| | Large bird | 16 | 2.0 | 398 | 1,500 | 0.011 | 0.0013 | 0.27 | I / I |
| Foliar Treatment Solutions (1%, 2% and 5%) | Small bird | 12 | 2.9 | 288 | 1,500 | 0.0077 | 0.0019 | 0.19 | I / I |
| | Large bird | 1.6 | 0.40 | 40 | 1,500 | 0.0011 | 0.0003 | 0.027 | I / I |
| **Rainfall Runoff, Maximum Treatment Scenario[1]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small bird | 0.012 | 0.0014 | 0.090 | 1,500 | 0.000008 | 0.0000009 | 0.00006 | **Pr / Pr** |
| | Large bird | 0.002 | 0.0002 | 0.012 | 1,500 | 0.000001 | 0.0000001 | 0.000008 | **Pr / Pr** |
| Long-term runoff[5] | Small Bird | 0.00009 | 0.000007 | 0.0063 | 58 | 0.000001 | 0.0000001 | 0.0001 | **Pr / Pr** |
| | Large Bird | 0.00001 | 0.0000009 | 0.0009 | 58 | 0.0000002 | 0.00000002 | 0.00001 | **Pr / Pr** |
| **Rainfall Runoff, Half-Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small bird | 0.0059 | 0.0007 | 0.045 | 1,500 | 0.000004 | 0.0000005 | 0.00003 | **Pr / Pr** |
| | Large bird | 0.0008 | 0.0001 | 0.0062 | 1,500 | 0.0000005 | 0.00000006 | 0.000004 | **Pr / Pr** |
| **Rainfall Runoff, Quarter-Treatment Scenario[3]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small bird | 0.0030 | 0.0004 | 0.022 | 1,500 | 0.000002 | 0.0000002 | 0.00001 | **Pr / Pr** |
| | Large bird | 0.0004 | 0.00005 | 0.0031 | 1,500 | 0.0000003 | 0.00000003 | 0.000002 | **Pr / Pr** |
| **Rainfall Runoff, Demonstration Project #4[4]** | | | | | | | | | |
| Peak runoff to Woodland Creek | Small bird | 0.0034 | 0.0004 | 0.025 | 1,500 | 0.000002 | 0.0000003 | 0.00002 | **Pr / Pr** |
| | Large bird | 0.0005 | 0.00005 | 0.0035 | 1,500 | 0.0000003 | 0.00000004 | 0.000002 | **Pr / Pr** |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

[1] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[2] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[3] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[4] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

[5] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.

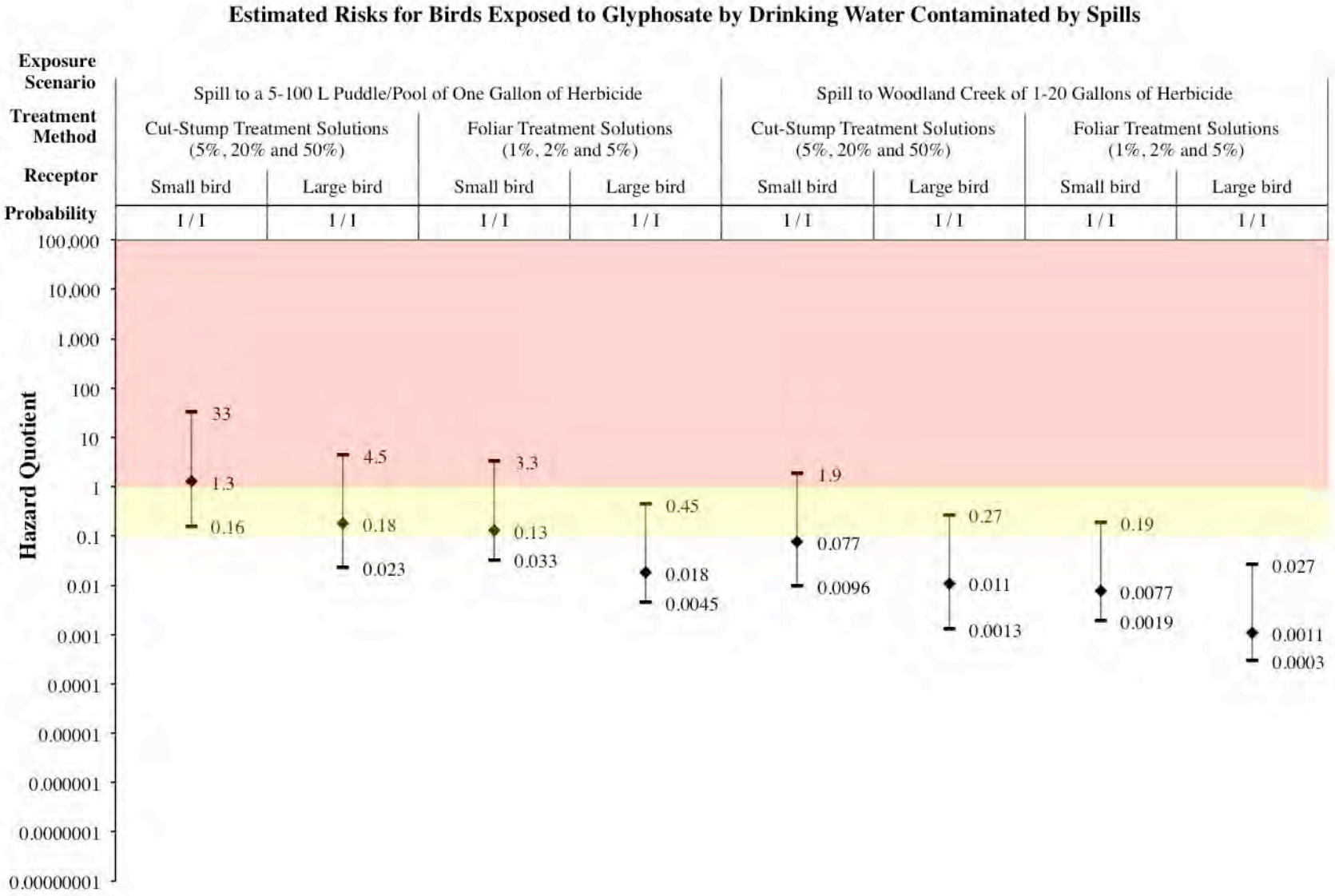



**Figure 3-9**: Estimated risks for birds exposed to glyphosate by drinking water contaminated by spills. See Table 3-21 above for data used to create this chart and definitions of terminology and abbreviations used.

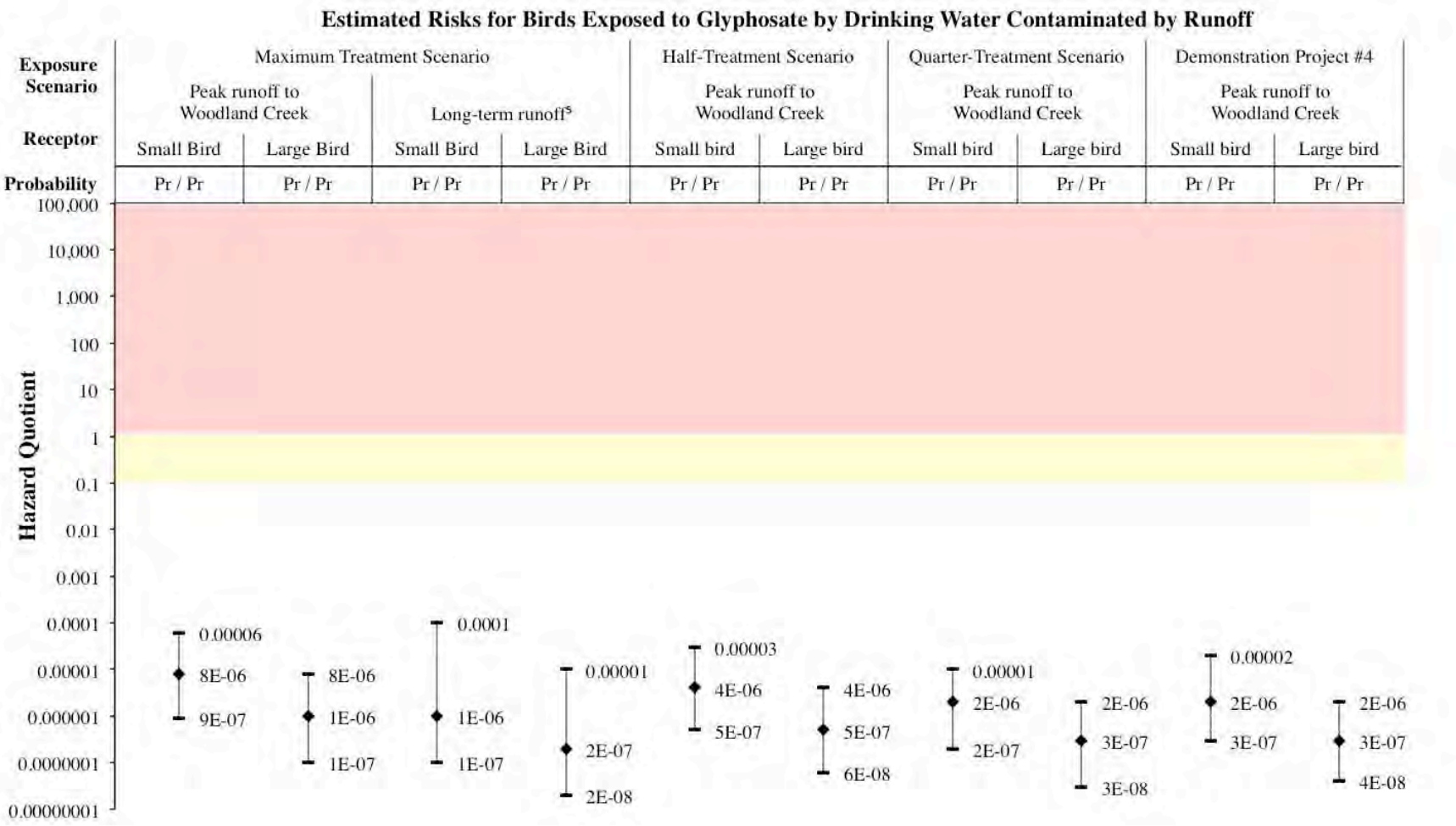



**Figure 3-10**: Estimated risks for birds exposed to glyphosate by drinking water contaminated by runoff. See Table 3-21 above for data used to create this chart and definitions of terminology and abbreviations used.

### *3.5.5.B Terrestrial Plants*

For terrestrial plants, unintended application will result in an exposure equivalent to the application rate. Most plants that receive glyphosate at or near the recommended range of application rates will be damaged. Glyphosate is unlikely to have significant residual herbicidal activity, since it adsorbs to soils and is poorly absorbed through plant roots.

At least 22 special-status plant species potentially occur in the general vicinity of Mount Sutro, based on the known range of these species; however, the Reserve provides suitable habitat for only two of these species—gumplant (*Grindelia hirsutula* var. maritima) and coastal triquetrella (*Triquetrella californica*).[216] If applicators are advised in recognizing these plants, risk to these two species can be minimized.

### *3.5.5.C Aquatic Wildlife*

The concentrations of glyphosate in water used for aquatic wildlife scenarios are the same as those used in the human and terrestrial exposure estimates for drinking water (see Table 3-13). Exposure estimates are compared to TRVs for less-toxic glyphosate formulations that do not contain the toxic POEA surfactant. Hazard quotients for amphibians and fish are summarized in Table 3-22 and Figure 3-11 and 3-12; for aquatic invertebrates in Table 3-23 and Figure 3-13; and for aquatic plants (algae only) in Table 3-24 and Figure 3-14. See Section 3.3.3.B for a discussion of amphibians found or potentially found within the Reserve and all of section 3.3.3 for the derivation of the TRVs for aquatic animals.

Spills represent the highest potential risk to aquatic wildlife, with estimated doses thousands of times the relevant TRVs for a one-gallon spill into a small (5 Liter) pool or puddle, or for a 20-gallon spill into Woodland Creek. Hazard Quotients greater than 1.0 would result from spills of one gallon of herbicide even at the lowest foliar concentrations—mixed to just one percent glyphosate acid. Spills are considered **Highly Improbable**, as long as the applicator guidelines in Section 2.5.1 are followed. Risks to aquatic life could be reduced by limiting use of glyphosate to areas distant from water bodies.

Runoff scenarios are the only **Probable** exposure for aquatic wildlife and most HQs for these scenarios are substantially lower than the TRVs. Risks from runoff can be minimized by treating fewer acres in a given watershed, particularly the Woodland Creek watershed, at the same time. Note that runoff to Woodland Creek is not applicable to Demonstration Project 1, which does not drain to the creek.

Because of lack of data, it was not possible to estimate levels of glyphosate in puddles or pools from overland flow, but concentrations of glyphosate may be high enough in puddles/pools adjacent to treatment sites that TRVs for amphibians, aquatic invertebrates and plants could be exceeded. Risks could be reduced by filling in ruts and depressions near treatment sites.

**Most Likely Exposures:** The aquatic scenarios considered **Probable** (for both the Main Project and the Demonstration Projects) are the scenarios for peak and long-term runoff to Woodland Creek and short-term runoff to the San Francisco Bay and the Pacific Ocean through wastewater treatment plants. No exposure estimates for glyphosate runoff scenarios exceed TRVs; however, in the Maximum treatment scenario, herbicide concentrations in Woodland Creek due to peak

runoff exceed 10 percent of the TRV for amphibians and aquatic invertebrates, at 15 percent and 12 percent respectively. No other **Probable** or **Possible** exposure estimate exceeds 10 percent of the relevant TRV.

1. **Sensitive species of amphibians exposed to herbicide runoff in Woodland Creek (Probable** for the Main Project or Demonstration Project 4; N/A to Demonstration Project 1).
   **Peak runoff:** The Upper estimate for this scenario is 15 percent of the TRV for amphibians if four pounds per acre of glyphosate is applied to all acres that drain to Woodland Creek. Central estimates are considerably lower and below levels of concern.
   **Long-term runoff:** Estimated amphibian exposures due to long-term runoff in Woodland Creek do not approach levels of concern in even the Maximum treatment scenario of four pounds per acre of glyphosate applied.

2. **Sensitive species of aquatic invertebrates exposed to herbicide runoff in Woodland Creek (Probable** for the Main Project or Demonstration Project 4; N/A to Demonstration Project 1).
   The Upper estimate for this scenario is 12 percent of the TRV for aquatic invertebrates if four pounds per acre of glyphosate is applied to all acres that drain to Woodland Creek. Central estimates are considerably lower and below levels of concern.

3. **Sensitive species of fish, aquatic invertebrates and aquatic plants exposed to herbicide runoff at wastewater treatment plant outfalls (Probable** for the Main Project or Demonstration Projects)
   **Peak runoff:** Estimated exposures of aquatic organisms (fish, invertebrates and plants) due to peak runoff to wastewater treatment plants are far below levels of concern for all taxa groups for even the Maximum treatment scenario of four pounds per acre of glyphosate applied. The highest Central exposure estimate for fish is 0.05 percent of the TRV and for aquatic invertebrates based on runoff to Oceanside WWTP after four pounds per acre are applied to all acres that drain to Oceanside WWTP. The worst-case Upper estimate for fish is 0.2 percent of the TRV, based on the same scenario.
   **Long-term runoff:** Long-term runoff to wastewater treatment plants was not considered because even peak runoff for even the Maximum treatment scenario of four pounds per acre of glyphosate applied does not approach levels of concern.

**Sensitive species of aquatic invertebrates exposed to herbicide runoff at wastewater treatment plant outfalls (Probable** for the Main Project or Demonstration Projects)

**Sensitive species of aquatic plants exposed to herbicide runoff in Woodland Creek (Probable** for the Main Project or Demonstration Project 4; N/A to Demonstration Project 1).
**Aquatic Plants, sensitive species, exposed to runoff to wastewater treatment plants (Probable** for the Main Project or Demonstration Projects)

**Highest Exposures:** It is also useful to consider the scenarios that yield the highest exposures, regardless of their probability, to evaluate the potential need for additional precautions that might be needed to protect aquatic wildlife. The highest hazard quotients calculated for any scenario

are for spills into a puddle or pool or Woodland Creek, considered **Highly Improbable**. Even Lower exposure estimates (which model spills of the least concentrated, one-percent glyphosate acid) exceeded TRVs for all but one scenario. For larger spills or higher concentrations of glyphosate, Lower exposure estimates exceeded TRVs by several orders of magnitude in most cases. The Central estimates ranged from 3.5 times the TRV for aquatic plants for a one-gallon spill into Woodland Creek to 3,880 times the TRV for amphibians exposed to a 20-gallon spill of 20 percent glyphosate solution into the creek. These estimates make clear that applicators should do everything possible to minimize the potential for a spill of glyphosate near water bodies.

1. **Spills of one gallon of herbicide to puddles or pools (Highly Improbable** for the Main Project or for the Demonstration Projects).
   Spills to puddles or pools represented the highest exposures of any kind, especially for a small (five liters) pool/puddle. Even a best-case (Lower) estimate of a one-gallon spill of a one-percent Aquamaster solution to a 100-liter pool resulted in an estimated dose 15 times the TRV for aquatic plants. For amphibians and aquatic invertebrates, this scenario produced even higher HQs, substantially above levels of concern.

2. **Spills of one gallon of herbicide to Woodland Creek (Highly Improbable** for the Main Project or Demonstration Project 4; not applicable to Demonstration Project 1).
   A one-gallon spill to Woodland Creek results in lower HQs than a spill into a pool or puddle, but still above the level of concern in all cases except the Lower estimate for aquatic plants. The most-likely (Central) estimated dose is 3.5 times the TRV for aquatic plants; the best-case (Lower) estimate is 88 percent of the TRV. HQs for aquatic invertebrates and amphibians are higher.

3. **Spills of 20 gallons of herbicide to Woodland Creek (Highly Improbable** for the Main Project and the Demonstration Projects).
   Twenty-gallon spills to Woodland Creek were calculated as a worst-case scenario. All estimated doses were found to be above the relevant TRVs for all three aquatic wildlife categories evaluated, even give best-case (Lower) assumptions. Specifically, the Lower estimated doses (one percent glyphosate acid spilled) are 97, 79 and 18 times the TRVs for amphibians, aquatic invertebrates and aquatic plants, respectively.

**Table 3-22: Estimated Risks for Sensitive Amphibians and Fish Exposed to Glyphosate-Contaminated Water**

| Receptor / Scenario | Concentration (mg/L) | | | Hazard Quotients | | | TRV | Scenario Probability (DP / Proj)[1] |
|---|---|---|---|---|---|---|---|---|
| | Central | Lower | Upper | Central | Lower | Upper | (mg/L) | |
| **Amphibians, Sensitive Species** | | | | | | | | |
| **Spills of Foliar Solutions (1%, 2% or 5%)** | | | | | | | | |
| Spill into puddle/pool, 1 gal | 725 | 181 | 18,138 | **330** | **82** | **8,244** | 2.2 | HI / HI |
| Spill into Woodland Creek, 1 gal | 43 | 11 | 267 | **19** | **4.8** | **121** | 2.2 | HI / HI |
| Spill into Woodland Creek, 20 gal | 853 | 213 | 5,335 | **388** | **97** | **2,425** | 2.2 | HI / HI |
| **Spills of Cut-Stump Solutions (5%, 20% or 50%)** | | | | | | | | |
| Spill into puddle/pool, 1 gal | 7,255 | 907 | 181,377 | **3,298** | **412** | **82,444** | 2.2 | HI / HI |
| Spill into Woodland Creek, 1 gal | 427 | 53 | 2,667 | **194** | **24** | **1,212** | 2.2 | HI / HI |
| Spill into Woodland Creek, 20 gal | 8,535 | 1,067 | 53,346 | **3,880** | **485** | **24,248** | 2.2 | HI / HI |
| **Rainfall Runoff, Maximum Treatment Scenario[2]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.044 | 0.0052 | 0.33 | 0.020 | 0.0024 | 0.15 | 2.2 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.0003 | 0.00003 | 0.023 | 0.0002 | 0.00001 | 0.013 | 1.8 | **Pr / Pr** |
| **Rainfall Runoff, Half Treatment Scenario[4]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.022 | 0.0026 | 0.17 | 0.010 | 0.0012 | 0.075 | 2.2 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.0002 | 0.00001 | 0.012 | 0.00009 | 0.000007 | 0.0064 | 1.8 | **Pr / Pr** |
| **Rainfall Runoff, Quarter Treatment Scenario[5]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.011 | 0.0013 | 0.083 | 0.0050 | 0.0006 | 0.038 | 2.2 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.00008 | 0.00001 | 0.0058 | 0.00004 | 0.000003 | 0.0032 | 1.8 | **Pr / Pr** |
| **Rainfall Runoff, Demonstration Plot #4[6]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.012 | 0.0015 | 0.094 | 0.0056 | 0.0007 | 0.043 | 2.2 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.00009 | 0.000007 | 0.0066 | 0.00005 | 0.000004 | 0.0036 | 1.8 | **Pr / Pr** |
| **Fish, Sensitive Species[7]** | | | | | | | | |
| **Rainfall Runoff, Maximum Treatment Scenario** | | | | | | | | |
| Peak runoff to Oceanside WWTP[8] | 0.0003 | 0.00007 | 0.0010 | 0.0005 | 0.00014 | 0.0020 | 0.5 | **Pr / Pr** |
| Peak runoff to Southeast WWTP[8] | 0.00002 | 0.00001 | 0.00009 | 0.00005 | 0.000013 | 0.00019 | 0.5 | **Pr / Pr** |
| **Rainfall Runoff, Half Treatment Scenario[4]** | | | | | | | | |
| Peak runoff to Oceanside WWTP[8] | 0.0001 | 0.00004 | 0.0005 | 0.00025 | 0.00007 | 0.0010 | 0.5 | **Pr / Pr** |
| Peak runoff to Southeast WWTP[8] | 0.00001 | 0.000003 | 0.00005 | 0.00002 | 0.000007 | 0.00009 | 0.5 | **Pr / Pr** |

| Receptor | Scenario | Concentration (mg/L) Central | Lower | Upper | Hazard Quotients Central | Lower | Upper | TRV (mg/L) | Scenario Probability (DP / Proj)[1] |
|---|---|---|---|---|---|---|---|---|---|
| **Rainfall Runoff, Quarter Treatment Scenario[5]** | | | | | | | | | |
| | Peak runoff to Oceanside WWTP[8] | 0.00006 | 0.00002 | 0.0002 | 0.00013 | 0.000036 | 0.0005 | 0.5 | **Pr / Pr** |
| | Peak runoff to Southeast WWTP[8] | 0.000006 | 0.000002 | 0.00002 | 0.000012 | 0.0000034 | 0.00005 | 0.5 | **Pr / Pr** |
| **Rainfall Runoff, Demonstration Plot #4[6]** | | | | | | | | | |
| | Peak runoff to Oceanside WWTP[8] | 0.00007 | 0.00002 | 0.00028 | 0.00014 | 0.000040 | 0.0006 | 0.5 | **Pr / Pr** |
| | Peak runoff to Southeast WWTP[8] | 0.000007 | 0.000002 | 0.00003 | 0.000013 | 0.000004 | 0.00005 | 0.5 | **Pr / Pr** |

TRV = Toxicity Reference Value; WWTP = Waste water treatment plant. Hazard Quotients above 0.1 are shaded. HQs greater than one are bolded.
[1] DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable
[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.
[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.
[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.
[7] Exposures for fish are not evaluated for Woodland Creek and puddle scenarios because there are no fish on Mount Sutro. The WWTP scenarios are not evaluated for amphibians because amphibians only live in fresh water.
[8] Peak runoff to Oceanside and Southeast WWTPs was estimated using USFS/GLEAMS herbicide runoff rates and WWTP capacities. See Section 2.5.2.H for details.

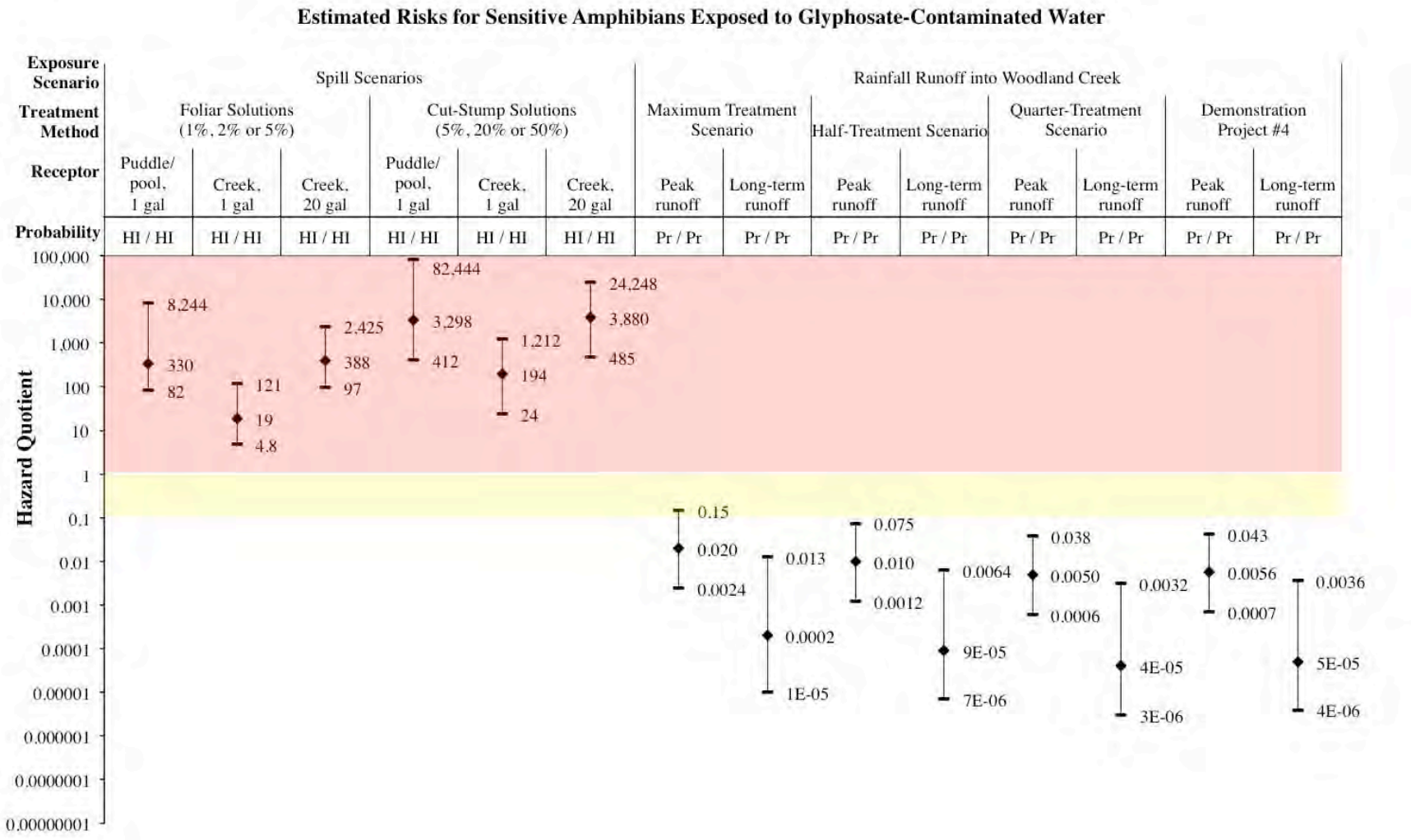



**Figure 3-11**: Estimated risks for sensitive species of amphibians exposed to glyphosate through spills and runoff into puddles/pools or runoff from treated areas. See Table 3-22 above for data used to create this chart and definitions of terminology and abbreviations used.

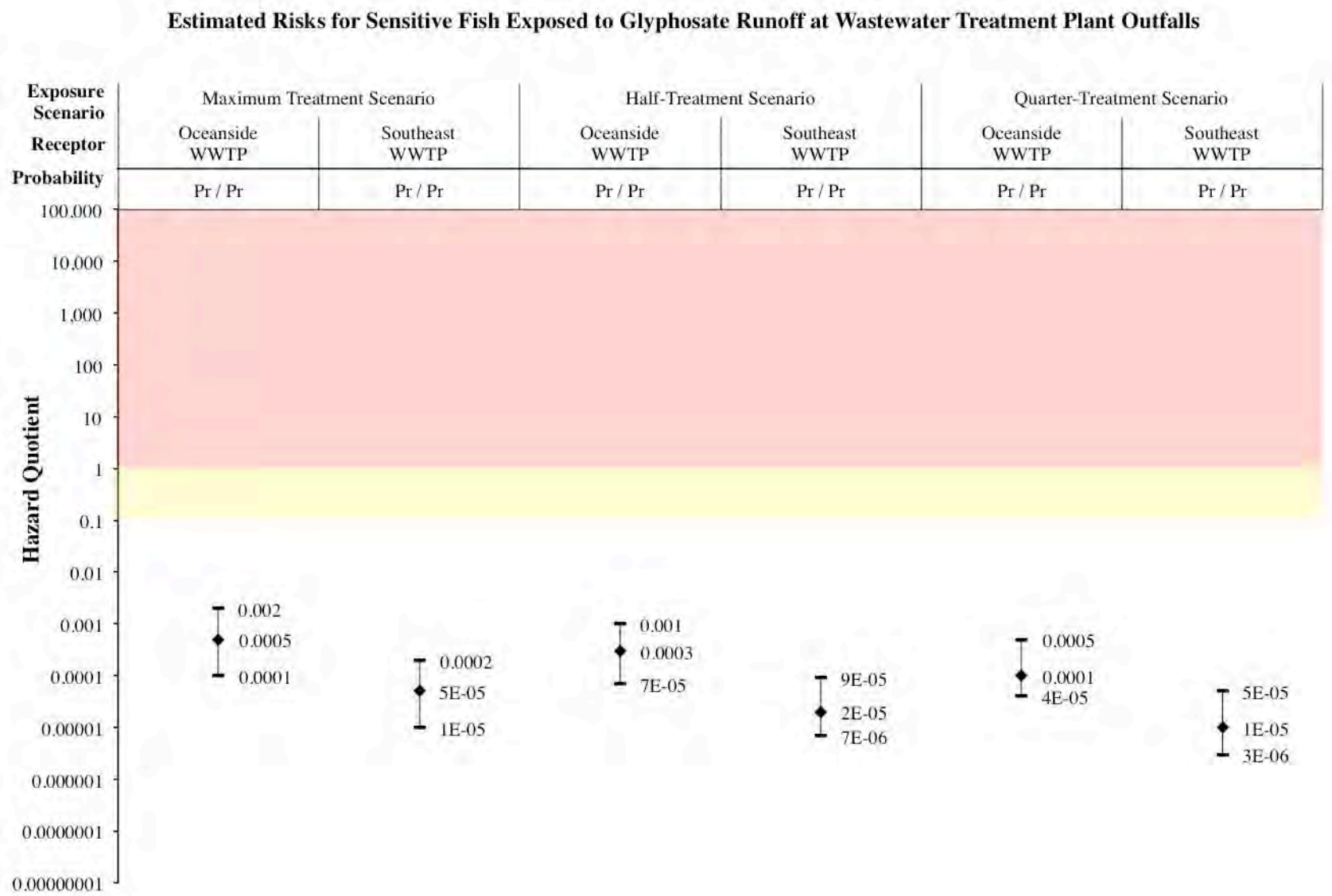



**Figure 3-12**: Estimated risks for sensitive species of fish from glyphosate runoff from treated areas to wastewater treatment plants. See Table 3-22 above for data used to create this chart and definitions of terminology and abbreviations used.

**Table 3-23: Estimated Risks for Sensitive Aquatic Invertebrates Exposed to Glyphosate-Contaminated Water**

| Receptor Scenario | Concentration (mg/L) Central | Lower | Upper | Hazard Quotients Central | Lower | Upper | TRV (mg/L) | Scenario Probability (DP / Proj)[1] |
|---|---|---|---|---|---|---|---|---|
| **Spills of Foliar Solutions (1%, 2% or 5%)** | | | | | | | | |
| Spill into puddle/pool, 1 gal | 725 | 181 | 18,138 | **269** | **67** | **6,718** | 2.7 | HI / HI |
| Spill into Woodland Creek, 1 gal | 43 | 11 | 267 | **16** | **3.9** | **99** | 2.7 | HI / HI |
| Spill into Woodland Creek, 20 gal | 853 | 213 | 5,335 | **316** | **79** | **1,976** | 2.7 | HI / HI |
| **Spills of Cut-Stump Solutions (5%, 20% or 50%)** | | | | | | | | |
| Spill into puddle/pool, 1 gal | 7,255 | 907 | 181,377 | **2,687** | **336** | **67,177** | 2.7 | HI / HI |
| Spill into Woodland Creek, 1 gal | 427 | 53 | 2,667 | **158** | **19.8** | **988** | 2.7 | HI / HI |
| Spill into Woodland Creek, 20 gal | 8,535 | 1,067 | 53,346 | **3,161** | **395** | **19,758** | 2.7 | HI / HI |
| **Rainfall Runoff, Maximum Treatment Scenario[2]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.044 | 0.0052 | 0.33 | 0.016 | 0.0019 | 0.12 | 2.7 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.0003 | 0.00003 | 0.023 | 0.0001 | 0.000009 | 0.0086 | 2.7 | **Pr / Pr** |
| Peak runoff to Oceanside WWTP[4] | 0.0003 | 0.00007 | 0.0010 | 0.00009 | 0.00003 | 0.0004 | 2.7 | **Pr / Pr** |
| Peak runoff to Southeast WWTP[4] | 0.00002 | 0.000007 | 0.00009 | 0.000009 | 0.000002 | 0.00003 | 2.7 | **Pr / Pr** |
| **Rainfall Runoff, Half Treatment Scenario[5]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.022 | 0.0026 | 0.17 | 0.0081 | 0.0010 | 0.061 | 2.7 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.0002 | 0.00001 | 0.012 | 0.00006 | 0.000005 | 0.0043 | 2.7 | **Pr / Pr** |
| **Rainfall Runoff, Quarter Treatment Scenario[6]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.011 | 0.0013 | 0.083 | 0.0041 | 0.0005 | 0.031 | 2.7 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.00008 | 0.00001 | 0.0058 | 0.00003 | 0.000002 | 0.0021 | 2.7 | **Pr / Pr** |
| **Rainfall Runoff, Demonstration Plot #4[7]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.012 | 0.0015 | 0.094 | 0.0046 | 0.0005 | 0.035 | 2.7 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.00009 | 0.000007 | 0.0066 | 0.00003 | 0.000003 | 0.0024 | 2.7 | **Pr / Pr** |

TRV = Toxicity Reference Value; WWTP = Waste water treatment plant. Hazard Quotients above 0.1 are shaded. HQs greater than one are bolded.

[1] DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.

[4] Peak runoff to Oceanside and Southeast WWTPs was estimated using USFS/GLEAMS herbicide runoff rates and WWTP capacities. See Section 2.5.2.H for details.

[5] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[6] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[7] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

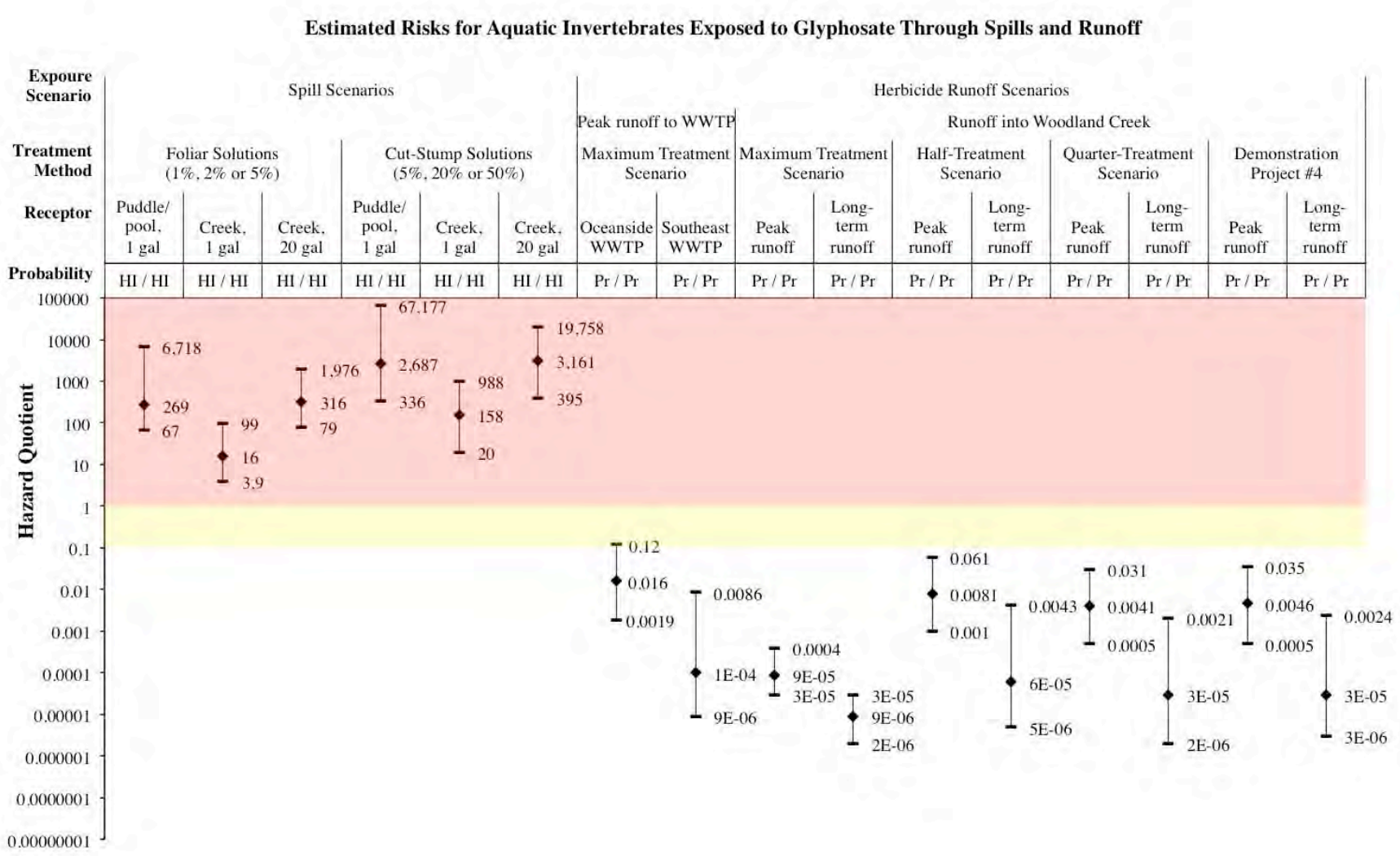



**Figure 3-13**: Estimated risks for aquatic invertebrates exposed to glyphosate through spills and runoff from treated areas. See Table 3-23 above for data used to create this chart and definitions of terminology and abbreviations used.

**Table 3-24: Estimated Risks for Aquatic Plants Exposed to Glyphosate-Contaminated Water**

| Receptor / Scenario | Concentration (mg/L) | | | Hazard Quotients | | | TRV | Scenario Probability (DP / Proj)[1] |
|---|---|---|---|---|---|---|---|---|
| | Central | Lower | Upper | Central | Lower | Upper | (mg/L) | |
| **Spills of Foliar Solutions (1%, 2% or 5%)** | | | | | | | | |
| Spill into puddle/pool, 1 gal | 725 | 181 | 18,138 | **60** | **15** | **1,499** | 12.1 | HI / HI |
| Spill into Woodland Creek, 1 gal | 43 | 11 | 267 | **3.5** | 0.88 | **22** | 12.1 | HI / HI |
| Spill into Woodland Creek, 20 gal | 853 | 213 | 5,335 | **71** | **18** | **441** | 12.1 | HI / HI |
| **Spills of Cut-Stump Solutions (5%, 20% or 50%)** | | | | | | | | |
| Spill into puddle/pool, 1 gal | 7,255 | 907 | 181,377 | **600** | **75** | **14,990** | 12.1 | HI / HI |
| Spill into Woodland Creek, 1 gal | 427 | 53 | 2,667 | **35** | **4.4** | **220** | 12.1 | HI / HI |
| Spill into Woodland Creek, 20 gal | 8,535 | 1,067 | 53,346 | **705** | **88** | **4,409** | 12.1 | HI / HI |
| **Rainfall Runoff, Maximum Treatment Scenario[2]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.044 | 0.0052 | 0.33 | 0.0036 | 0.0004 | 0.027 | 12.1 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.0003 | 0.00003 | 0.023 | 0.00003 | 0.000002 | 0.0019 | 12.1 | **Pr / Pr** |
| Peak runoff to Oceanside WWTP[4] | 0.0003 | 0.00007 | 0.0010 | 0.00002 | 0.000006 | 0.00008 | 12.1 | **Pr / Pr** |
| Peak runoff to Southeast WWTP[4] | 0.00002 | 0.000007 | 0.00009 | 0.000002 | 0.0000006 | 0.000008 | 12.1 | **Pr / Pr** |
| **Rainfall Runoff, Half Treatment Scenario[5]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.022 | 0.0026 | 0.17 | 0.0018 | 0.0002 | 0.014 | 12.1 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.0002 | 0.00001 | 0.012 | 0.00001 | 0.000001 | 0.0010 | 12.1 | **Pr / Pr** |
| **Rainfall Runoff, Quarter Treatment Scenario[6]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.011 | 0.0013 | 0.083 | 0.0009 | 0.0001 | 0.007 | 12.1 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.00008 | 0.00001 | 0.0058 | 0.000007 | 0.0000005 | 0.0005 | 12.1 | **Pr / Pr** |
| **Rainfall Runoff, Demonstration Plot #4[7]** | | | | | | | | |
| Peak runoff into Woodland Creek[3] | 0.012 | 0.0015 | 0.094 | 0.0010 | 0.0001 | 0.0078 | 12.1 | **Pr / Pr** |
| Long-term runoff into Woodland Creek[3] | 0.00009 | 0.000007 | 0.0066 | 0.000007 | 0.0000006 | 0.0005 | 12.1 | **Pr / Pr** |

TRV = Toxicity Reference Value; WWTP = Waste water treatment plant. Hazard Quotients above 0.1 are shaded. HQs greater than one are bolded.

[1] DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.

[4] Peak runoff to Oceanside and Southeast WWTPs was estimated using USFS/GLEAMS herbicide runoff rates and WWTP capacities. See Section 2.5.2.H for details.

[5] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[6] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[7] The Demonstration Project #4 scenario is two out of the 7.08 acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

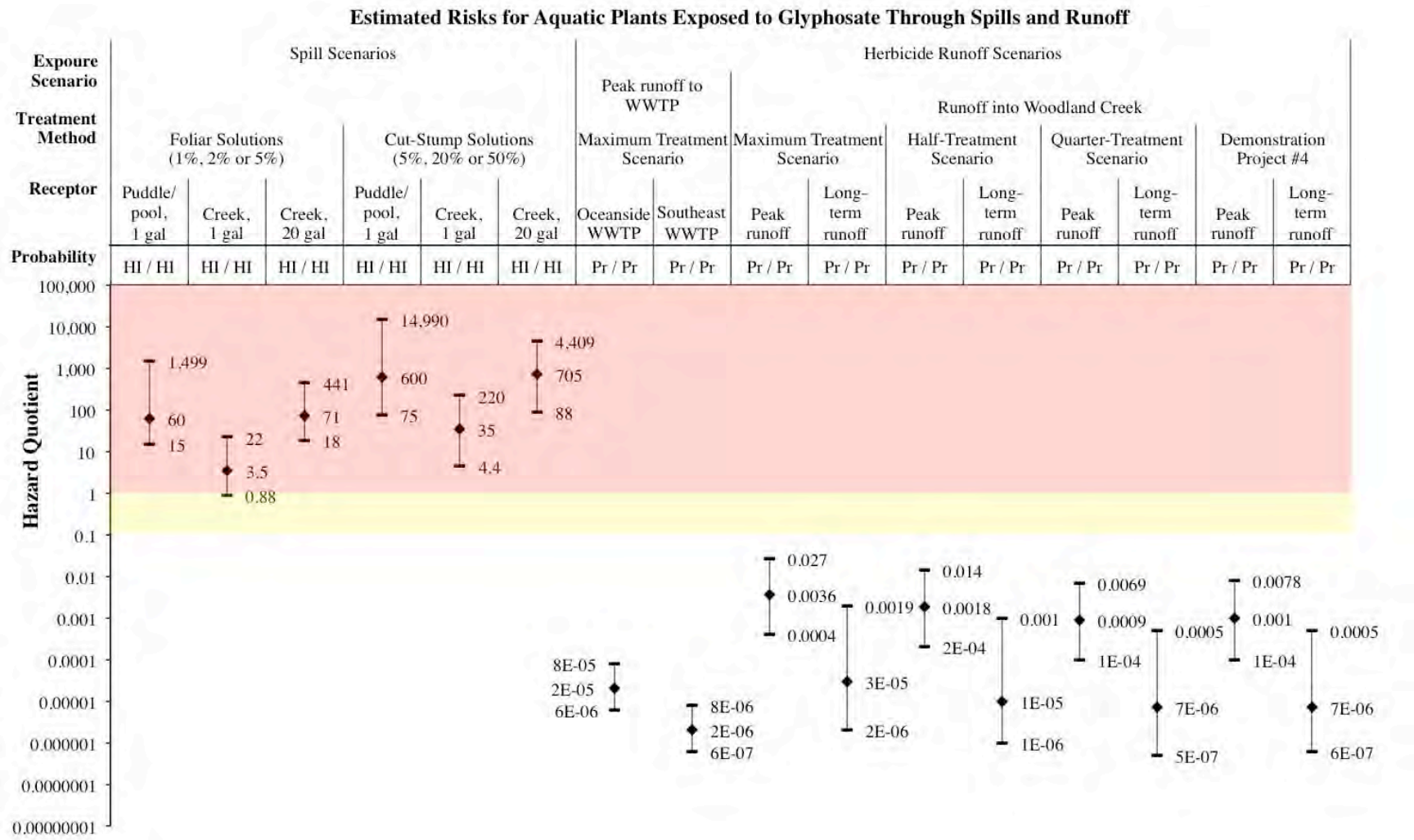



**Figure 3-14**: Estimated risks for aquatic plants exposed to glyphosate through spills and runoff. See Table 3-24 above for data used to create this chart and definitions of terminology and abbreviations used.

# References for Chapter 3

[1] US EPA. 2011. Grube A, Donaldson D, Kiely T, Wu L. *Pesticide Industry Sales and Usage 2006 and 2007 Market Estimates,* US Environmental Protection Agency. http://www.epa.gov/opp00001/pestsales/.

[2] California CA Department of Pesticide Regulation (DPR), *Reports of Pesticides Sold in California.* Department of Pesticide Regulation. http://www.cdpr.ca.gov/docs/mill/nopdsold.htm.

[3] European Commission (EC). 2002. *Review Report for the Active Substance Glyphosate*. European Commission, Health and Consumer Protection Directorate-General, Directorate E1—Plant Health. 6511/VI/99-final. January 21, 2002. http://ec.europa.eu/food/plant/protection/evaluation/existactive/list1_glyphosate_en.pdf.

[4] SERA. 1997. Effects of Surfactants on the Toxicity of Glyphosate, with Specific Reference to RODEO. Syracuse Environmental Research Associates. February 6, 1997. http://www.fs.fed.us/foresthealth/pesticide/pdfs/Surfactants.pdf.

[5] USFS. 2011. Glyphosate human health and ecological risk assessment final report. Prepared for the US Forest Service by Syracuse Environmental Research Associates. http://www.fs.fed.us/foresthealth/pesticide/pdfs/Glyphosate_SERA_TR-052-22-03b.pdf.

[6] US EPA. 1993. *Glyphosate Re-registration Eligibility Decision (RED).* 1993. US Environmental Protection Agency. EPA-738-R-93-014. Washington, DC. http://www.epa.gov/oppsrrd1/REDs/old_reds/glyphosate.pdf.

[7] US EPA 2006. Glyphosate Human Health Risk Assessment for Proposed Uses on Safflower and Sunflower. PC Code: 103601, Petition No: 4E6878, DP Num: 314476. Docket # EPA-HQ-OPP-2006-0177-0006.

[8] US EPA. 2008. Glyphosate: Effects determination for the California red-legged frog. US Environmental Protection Agency. http://www.epa.gov/espp/litstatus/effects/redleg-frog/#glyphosate.

[9] US EPA. *Ecotox database*. US Environmental Protection Agency. http://www.epa.gov/ecotox.

[10] WHO. 1994. *Environmental Health Criteria 159: Glyphosate*. World Health Organization International Programme on Chemical Safety. http://www.inchem.org/documents/ehc/ehc/ehc159.htm.

[11] CA OEHHA. 2007. *Public Health Goal for Glyphosate in Drinking Water.* California Office of Environmental Health Hazard Assessment, June 2007. http://www.oehha.org/water/phg/gly062907.html.

[12] Ascherio A, Chen H, Weisskopf MG, et al. 2006. Pesticide exposure and risk for Parkinson's disease. *Ann Neurol* 60(2): 197-203.

[13] Bradberry SM, Proudfoot AT, Vale JA. 2004. Glyphosate poisoning. *Toxicol Rev* 23(3): 159-167.

[14] Penagos H, Ruepert C, Partanen T, et al. 2004. Pesticide patch test series for the assessment of allergic contact dermatitis among banana plantation workers in Panama. *Dermatitis* 15(3): 137-145.

[15] Hindson C, Diffey B. 1984. Phototoxicity of glyphosate in a weedkiller. *Contact Dermatitis* 10(1): 51-52.

[16] Hindson C, Diffey B. 1984. Phototoxicity of a weedkiller: a correction. *Cont. Dermatitis* 11: 260.

[17] Rodriguez AS, Olaguibel JM, Garcia BE et al. 1997. Occupational contact allergy to herbicide glyphosphate. *J Aller Clin Immunol* 99(1 Part 2): S336.

[18] Acquavella JF, Weber JA, Cullen MR, et al. 1999. Human ocular effects from self-reported exposures to Roundup herbicides. *Hum Exp Toxicol* 18(8): 479-486.

[19] Temple WA, Smith NA. 1992. Glyphosate herbicide poisoning experience in New Zealand. *New Zeal Med J* 105(933): 173-174.

[20] Lee HL, Chen KW, Chi CH, et al. 2000. Clinical presentations and prognostic factors of a glyphosate-surfactant herbicide intoxication: a review of 131 cases. *Acad Emerg Med* 7(8): 906-910.

[21] Lin CM, Lai CP, Fang TC, et al. 1999. Cardiogenic shock in a patient with glyphosate-surfactant poisoning. *J Formos Med Assoc* 98(10): 698-700.

[22] Menkes DB, Temple WA, Edwards IR. 1991. Intentional self-poisoning with glyphosate- containing herbicides. *Hum Exp Toxicol* 10(2): 103-107.

[23] Moon JM, Min YI, Chun BJ. 2006. Can early hemodialysis affect the outcome of the ingestion of glyphosate herbicide? *Clin Toxicol* 44(3): 329-332.

[24] Sawada Y, Nagai Y, Ueyama M, et al. 1988. Probable toxicity of surface-active agent in commercial herbicide containing glyphosate (letter). *Lancet* 1: 299.

[25] Stella J, Ryan M. 2004. Glyphosate herbicide formulation: a potentially lethal ingestion. *Emerg Med Australas* 16(3): 235-239.

[26] Sampogna RV, Cunard R. 2007. Roundup intoxication and a rationale for treatment. *Clin Nephrol* 68(3): 190-196.

[27] Chang CY, Peng YC, Hung DZ, et al. 1999. Clinical impact of upper gastrointestinal tract injuries in glyphosate-surfactant oral intoxication. *Hum Exp Toxicol* 18(8): 475-478.

[28] Hung DZ, Deng JF, Wu TC. 1997. Laryngeal survey in glyphosate intoxication: a pathophysiological investigation. *Hum Exp Toxicol* 16(10): 596-599.

[29] Talbot AR, Shiaw MH, Huang JS, et al. 1991. Acute poisoning with a glyphosate-surfactant herbicide ('Roundup'): a review of 93 cases. *Hum Exp Toxicol* 10(1): 1-8.

[30] Tominack RL, Yang G-Y, Tsai W-J, et al. 1991. Taiwan National Poison Center survey of glyphosate-surfactant herbicide ingestions. *J Toxicol Clin Toxicol* 29(1): 91-110.

[31] US EPA 2007. *Chemicals Evaluated for Carcinogenic Potential.* US Environmental Protection Agency, Science Information Management Branch, Health Effects Division, Office of Pesticide Programs. US Environmental Protection Agency. Washington, DC. September 9, 2007.

[32] Hardell L, Eriksson M. 1999. A case-control study of non-Hodgkin lymphoma and exposure to pesticides. *Cancer* 85(6): 85: 1353-1360.

[33] Acquavella J, Farmer D, Cullen MR. 1999. A case-control study of non-Hodgkin lymphoma and exposure to pesticides [letter]. *Cancer* 86(4): 729-731. http://www.monsanto.com/monsanto/content/ products/productivity/ roundup/nhl_backgr.pdf.

[34] Hardell L, Eriksson M, Nordstrom M. 2002. Exposure to pesticides as risk factor for non-Hodgkin's lymphoma and hairy cell leukemia: pooled analysis of two Swedish case-control studies. *Leuk Lymph* 43(5): 1043-1049.

[35] Nordstrom M, Hardell L. Magnuson A, et al. 1998. Occupational exposures, animal exposure and smoking as risk factors for hairy cell leukaemia evaluated in a case-control study. *Br J Can* 77(11): 2048-2052.

[36] Monsanto Company. 2002. *Backgrounder. Glyphosate: Response to Hairy Cell Leukemia Allegations.* Monsanto Company. August 2002.
http://www.monsanto.com/monsanto/content/products/productivity/roundup/gly_hcl_bkgd.pdf.

[37] Eriksson, M, Hardell, L, Michael Carlberg, M and Akerman, M. 2008. Pesticide exposure as risk factor for non-Hodgkin lymphoma including histopathological subgroup analysis. *Int J Cancer.* 123: 1657-1663.

[38] McDuffie HH, Pahwa P, McLaughlin JR, et al. 2001. Non-Hodgkin's lymphoma and specific pesticide exposures in men: cross-Canada study of pesticides and health. *Can Epid Biomark Prev* 10(11): 1155-1163.

[39] DeRoos AJ, Zahm SH, Cantor KP, et al. 2003. Integrative assessment of multiple pesticides as risk factors for non-Hodgkin's lymphoma among men. *Occ Environ Med* 60(9): E11.

[40] Alavanja MCR, Sandler DP, McMaster SB, et al. 1996. Agricultural Health Study. *Environ Health Perspect* 104**:** 362-369.

[41] DeRoos AJ, Blair A, Rusiecki, JA, et al. 2005. Cancer incidence among glyphosate-exposed pesticide applicators in the Agricultural Health Study. *Environ Health Perspect* 113: 49-54.

[42] Bolognesi C, Carrasquilla G, Volpi S, *et al*. 2009. Biomonitoring of genotoxic risk in agricultural workers from five Colombian regions: association to occupational exposure to glyphosate. *J Toxicol Environ Health A.* 72(15-16): 986-97.

[43] Paz-y-Miño C, Sánchez ME, Arévalo M, et al. 2007. Evaluation of DNA damage in an Ecuadorian population exposed to glyphosate. *Genet Mol Biol* 30(2): 1415-4757.

[44] Slager RE, Simpson SL, Levan TD, Poole JA, Sandler DP, Hoppin JA. 2010. Rhinitis associated with pesticide use among private pesticide applicators in the agricultural health study. *J Toxicol Environ Health A.* 73(20): 1382-93.

[45] Arbuckle TE, Lin Z, Mery LS. 2001. An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. *Environ Health Persp* 109(8): 851-857.

[46] Curtis KM, Savitz D, Weinberg CR et al. 1999. The effect of pesticide exposure on time to pregnancy. *Epidemiology* 10(2): 112-117.

[47] Savitz DA, Arbuckle T, Kaczor D, *et al.* 1997. Male pesticide exposure and pregnancy outcome. *Am J Epidemiol* 146(12): 1025-1036.

[48] Rull RP, Ritz B, Shaw GM. 2004. Neural tube defects and maternal residential proximity to agricultural pesticide applications. *Epidemiology* 15(4): S188.

[49] Wilson RD, Johnson JA, Wyatt P, et al. 2007. Pre-conceptional vitamin/folic acid supplementation 2007: the use of folic acid in combination with a multivitamin supplement for the prevention of neural tube defects and other congenital anomalies. *J Obstet Gynaecol Can* (12): 1003–1026.

[50] Garry VF, Harkins ME, Erickson LL, et al. 2002. Birth Defects, Season of conception, and Sex of children Born to Pesticide Applicators Living in the Red River Valley of Minnesota, USA. *Environ Health Persp* 110(Suppl 3): 441–449.

[51] Barbosa ER, Leiros da Costa MD, Bacheschi LA, et al. 2001. Parkinsonism after glycine-derivate exposure. *Mov Disord* 16(3): 565-568.

[52] Kamel F, Tanner C, Umbach D, et al. 2007. Pesticide exposure and self-reported Parkinson's disease in the Agricultural Health Study. *Am J Epidemiol* 165(4): 364-374.

[53] Wester RC, Melendres J, Serranzana S, et al. 1991. Glyphosate skin binding, absorption, residual tissue distribution, and skin decontamination. *Fund Appl Toxicol* 16(4): 725-743.

[54] Wester RC, Quan D, Maibach HI. 1996. In vitro percutaneous absorption of model compounds glyphosate and malathion from cotton fabric into and through human skin. *Food Chem Toxicol* 34(8): 731-735.

[55] Maibach HI. 1986. Irritation, sensitization, photoirritation and photosensitization assays with a glyphosate herbicide. *Contact Dermatitis* 15(3): 152-156.

[56] Schneider F, Edmiston E, Spencer JE, et al, 1999. Exposure of hand applicators to glyphosate in forest settings, 1995. Report # HS-1764.

[57] Jauhiainen A, Rasanen K, Sarantila R, et al. 1991. Occupational exposure of forest workers to glyphosate during brush saw spraying work. *Am Ind Hyg Assoc J* 52(2): 61-64.

[58] OSHA. *Glyphosate.* Occupational Safety and Health Administration, Department of Labor. http://www.osha.gov/dts/sltc/methods/partial/t-pv2067-01-8911-ch/t-pv2067-01-8911-ch.html.

[59] Vasiluk L, Pinto LJ, Moore MM. 2005. Oral bioavailability of glyphosate: studies using two intestinal cell lines. *Environ Toxicol Chem* 24(1): 153-160.

[60] Mori H, Sato T, Nagase H, et al. 1998. Analytical method for screening and quantification of phosphated amino acid herbicides in the serum of acutely intoxicated patients using HPLC with a diode-array-detector. *Japan J Toxicol Environ Health* 44(4): 245-255.

[61] Cartigny B, Azaroual N, Imbenotte M, et al. 2004. Determination of glyphosate in biological fluids by $^{1}H$ and $^{31}P$ NMR spectroscopy. *Forensic Sci Int* 143(2-3): 141-145.

[62] Curwin BD, Hein MJ, Sanderson WT, et al. 2007. Urinary pesticide concentrations among children, mothers and fathers living in farm and non-farm households in Iowa. *Ann Occ Hyg* 51(1): 53-65.

[63] Curwin BD, Hein MJ, Sanderson WT, et al. 2007. Pesticide dose estimates for children of Iowa farmers and non-farmers. *Environ Res* 105(3): 307-315.

[64] Cowell JE, Steinmetz JR. 1990. *Assessment of forest worker exposures to glyphosate during backpack foliar applications of Roundup 7 herbicide.* Monsanto Report No. MSL-9656.

[65] Jauhiainen A, Rasanen K, Sarantila R, *et al.* 1991. Occupational exposure of forest workers to glyphosate during brush saw spraying work. *Am Ind Hyg Assoc J* 52(2): 61-64.

[66] Lavy TL, Cowell JE, Steinmetz JR, et al. 1992. Conifer seedling nursery worker exposure to glyphosate. *Arch Environ Contam Tox* 22: 6-13.

[67] Middendorf PJ. 1993, as cited in Reference 4.

[68] Lavy TL, Norris LA, Mattice JD, *et al.* 1987. Exposure of forestry ground workers to 2,4-D, picloram and dichlorprop. *Envi Toxicol Chem* 6:209–224.

[69] Baker BA, Alexander BH, Mandel JS, et al. 2005. Farm Family Exposure Study: methods and recruitment practices for a biomonitoring study of pesticide exposure. *J Expo Anal Environ Epid* 2(5): 802.

[70] *The Farm Family Exposure Study.* Bayer, Dow Agrosciences, DuPont, FMC, Monsanto, Syngenta, and the American Chemistry Council. http://www.farmfamilyexposure.org.

[71] Acquavella JF, Alexander BH, Mandel JS, et al. 2006. Exposure misclassification in studies of agricultural pesticides: insights from biomonitoring. *Epidemiology* 17(1): 69-74.

[72] *American Association of Poison Control Centers.* http://www.aapcc.org/DNN/.

[73] Calvert GM, Plate DK, Das R, et al. 2004. Acute occupational pesticide-related illness in the US, 1998-1999: surveillance findings from the SENSOR-pesticides program. *Am J Ind Med* 45(1): 14-23.

[74] Calvert GM, Mehler LN, Rosales R, et al. 2003. Acute pesticide-related illnesses among working youths, 1988-1999. *Am J Public Health* 93(4): 605-610.

[75] Calvert GM, Petersen AM, Sievert J, *et al.* 2007. Acute pesticide poisoning in the U.S. retail industry, 1998-2004. *Public Health Rep* 122(2): 232-244.

[76] CA DPR. 1996. *Overview of the California Pesticide Illness Surveillance Program—1996.* California Department of Pesticide Regulation Worker Health and Safety Branch. Health and Safety Report HS-1776. http://www.cdpr.ca.gov/docs/whs/pdf/hs1776.pdf.

[77] Goldstein DA, Acquavella JF, Mannion RM, et al. 2002. An analysis of glyphosate data from the California Environmental Protection Agency Pesticide Illness Surveillance Program. *J Toxicol Clin Toxicol* 40(7): 885-892.

[78] Iowa Department of Public Health. 2002. *Pesticide Exposure Surveillance Program.* Iowa Department of Public Health. http://www.idph.state.ia.us/eh/common/pdf/pesticides/2002_annual_pesticide_report.pdf. For 2003 and 2004 reports substitute that year in the url.

[79] Washington State Department of Health. *DOH Pesticide Illness Data.* Washington State Department of Health. http://www.doh.wa.gov/ehp/Pest/pest-illness-data.htm#investigation.

[80] Michigan. *Pesticide Illness Annual Reports.* 2003 and 2006. http://www.michigan.gov/documents/Pesticides_Annual_report_2003_finajpeg_127710_7.pdf

http://www.michigan.gov/documents/mdch/Pesticides_Annual_Report2006_222912_7.pdf.

[81] CA DPR. *Pesticide Illness Surveillance Program.* California Department of Pesticide Regulation. http://www.cdpr.ca.gov/docs/whs/pisp.htm.

[82] Robinson J. *VPIC Data Report.* Melbourne: Victorian Posions Information Centre, 1998–2002.

[83] Davanzo F, Settimi L, Faraoni L, et al. 2004. Agricultural pesticide-related poisonings in Italy: cases reported to the Poison Control Centre of Milan in 2000-2001. *Epidemiol Prev* 28(6): 330-337.

[84] Monsanto, 1998 in CA OEHHA 2007, reference 11.

[85] Anadón A, Martínez-Larrañaga MR, Martínez MA, *et al*. 2009. Toxicokinetics of glyphosate and its metabolite aminomethyl phosphonic acid in rats. *Toxicol Lett* 190(1): 91-5.

[86] Mose, T, Kjaerstad, MB, Mathiesen, L, Nielsen, JB, Edelfors, S, Knudsen, LE. 2008. Placental passage of benzoic acid, caffeine, and glyphosate in an ex vivo human perfusion system. *J Toxicol Environ Health Part A* 71: 984-991.

[87] Poulsen MS, Rytting E, Mose T, Knudsen LE. 2009. Modeling placental transport: correlation of in vitro BeWo cell permeability and ex vivo human placental perfusion. *Toxicol In Vitro* 23(7): 1380-6.

[88] Wester, *et al.*, in CA OEHHA 2007, reference 11.

[89] Monsanto, 1979b and 1979c in CA OEHHA 2007, reference 11.

[90] Heydens, 1988 in CA OEHHA 2007, reference 11.

[91] Monsanto, 1971, 1975, and 1979a; Branch et al., 1983 in CA OEHHA 2007, reference 11.

[92] Adam A, Marzuki A, Rahman HA, et al. 1997. The oral and intratracheal toxicities of Roundup and its components to rats. *Vet Hum Toxicol* 39(3): 147–151.

[93] Dallegrave et al. 2003 in CA OEHHA 2007, reference 11.

[94] Dallegrave E, Mantese FD, Oliveira RT, *et al*. 2007. Pre- and postnatal toxicity of the commercial glyphosate formulation in Wistar rats. *Arch Toxicol* 81(9): 665-73.

[95] Romano RM, Romano MA, Bernardi MM, *et al*. 2010. Prepubertal exposure to commercial formulation of the herbicide glyphosate alters testosterone levels and testicular morphology. *Arch Toxicol* 84(4):309-17.

[96] Bio/Dynamics Inc, 1981b in CA OEHHA 2007, reference 11.

[97] Monsanto, 1990b in CA OEHHA 2007, reference 11.

[98] Daruich et al. 2001 in CA OEHHA 2007, reference 11.

[99] Yousef et al. 1995 in CA OEHHA 2007, reference 11.

[100] IRDC, 1980a in CA OEHHA 2007, reference 11.

[101] IRDC, 1980b in CA OEHHA 2007, reference 11.

[102] EC. 2000. Towards the establishment of a priority lists of substances for further evaluation of their role in endocrine disruption: Preparation of a candidate list of substances as a basis for priority setting. European Commission DG ENV. June 21, 2000. M0355008/1786Q. http://ec.europa.eu/environment/docum/01262_en.htm#bkh.

[103] PANNA. 2008. Glyphosate. *PesticideInfo Web Site.* Pesticide Action Network North America. http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC33138.

[104] Lin N, Garry VF. 2000. In vitro studies of cellular and molecular developmental toxicity of adjuvants, herbicides, and fungicides commonly used in Red River valley, Minnesota. *J Toxicol Environ Health, Part A* 60: 423–439.

[105] Petit F, Le Goff P, Cravédi J-P, et al. 1997. Two complementary bioassays for screening the estrogenic potency of xenobiotics: recombinant yeast for trout estrogen receptor and trout hepatocyte cultures. *J Molec Endrocrinology* 19: 321–335.

[106] Walsh LP, McCormick C, Martin C, Stocco DM. 2000. Roundup inhibits steroidogenesis by disrupting steroidongenic acute regulatory (StAR) protein expression. *Environ Health Persp* 108(8): 769–776.

[107] Gasnier C, Dumont C, Benachour N, Clair E, Chagnon MC, Séralini GE, 2009. Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines. *Toxicology* 262:184–191.

[108] Richard S. Moslemi S, Sipahutar H, et al. 2005. Differential Effects of Glyphosate and Roundup on Human Placental Cells and Aromatase. *Envi Health Persp* 113(6): 716–720.

[109] Benachour H, Sipahutar S, Moslemi C, *et al.* 2007. Time- and Dose-Dependent Effects of Roundup on Human Embryonic and Placental Cells. *Arch Environ Tox*, DOI: 10.1007/s00244-006-0154-8. http://www.springerlink.com/content/d13171q7k863l446/fulltext.html.

[110] Benachour N, Séralini GE, 2009. Glyphosate formulations induce apoptosis and necrosis in human umbilical, embryonic, and placental cells. *Chem Res Toxicol* 22(1):97-105.

[111] Gasnier C, Benachour N, Clair E, *et al.* 2010. Dig1 protects against cell death provoked by glyphosate-based herbicides in human liver cell lines. *J Occup Med Tox* 5:29. http://www.occup-med.com/content/5/1/29.

[112] Paganelli A, Gnazzo V, Acosta H, Lopez SL, Carrasco AE, 2010. Glyphosate-based herbicides produce teratogenic effects on vertebrates by impairing retinoic acid signaling. *Chem Research Toxicol* 23:1586–1595.

[113] Retinoic acid plays a role in mediating the development of the neural crest cells as they differentiate and proliferate into bone, cartilage, neurons, and smooth muscle tissue in developing vertebrates.

[114] a) US Geological Survey 2007. *Concentrations of Glyphosate, Its Degradation Product, Aminomethylphosphonic Acid, and Glufosinate in Ground- and Surface-Water, Rainfall, and Soil Samples Collected in the United States, 2001–06.* Scientific Investigations Report 2007–5122.

b) Battaglin WA, Kolpin DW, Scribner EA, *et al.* 2005. Glyphosate, other herbicides and transformation products in Midwestern streams, 2002. *J Amer Water Resources Assoc.* 41(2): 323–332.

[115] Saltmiras D, Bus JS, Spanogle T, *et al.* 2011. Letter to the editor regarding the article by Paganelli *et al. Chem Research Toxicol* 24:607–608.

[116] Carrasco A, 2011. Reply to the letter to the editor regarding our article (Paganelli *et al.* 2010). *Chem Research Toxicol* 24:610–613.

[117] US EPA. *Endocrine Disruptor Screening Program.* US Environmental Protection Agency, http://www.epa.gov/scipoly/oscpendo/index.htm.

[118] US EPA. 2007. *Assay Development and Validation.* US Environmental Protection Agency. http://www.epa.gov/scipoly/oscpendo/pubs/assayvalidation/index.htm.

[119] US NTP. 2008. *Endocrine Disruptor: Overview of Projects*, US National Toxicology Program. April 4, 2008. http://iccvam.niehs.nih.gov/methods/endocrine/endocrine.htm

[120] US NTP 2003. *Endocrine Disruptor: Test Method Evaluation Report*. US National Toxicology Program. April 15, 2008. http://iccvam.niehs.nih.gov/methods/endocrine/end_TMER.htm

[121] US EPA. 2007. *Overview of the June 2007 Draft List of Chemicals for Initial Tier 1 Screening.* US Environmental Protection Agency, http://www.epa.gov/scipoly/oscpendo/pubs/prioritysetting/listfacts.htm.

[122] US EPA. 2007. *Draft Policies and Procedures for the Endocrine Disruptor Screening Program.* US Environmental Protection Agency, http://www.epa.gov/scipoly/oscpendo/pubs/regaspects/index.htm.

[123] a) US EPA, 2009. Endocrine Disruptor Screening Program; Policies and Procedures for Initial Screening. *Fed Regis* 74(71): 17560-17579. Wednesday, April 15, 2009.

b) US EPA, 2009. Final List of Initial Pesticide Active Ingredients and Pesticide Inert Ingredients to be Screened Under the Federal Food, Drug, and Cosmetic Act. *Fed Regis* 74(71): 17579-17585. Wednesday, April 15, 2009.

[124] Caglar S, Kolankaya D. 2008. The effect of sub-acute and sub-chronic exposure of rats to the glyphosate-based herbicide Roundup. *Environ Toxicol Pharmacol* 25: 57–62.

[125] Monsanto, 1979d in CA OEHHA 2007, reference 11.

[126] Monsanto, 1987 in WHO 1994, reference 10.

[127] NTP, 1992 in CA OEHHA 2007, reference 11.

[128] Monsanto, 1985 in CA OEHHA 2007, reference 11.

[129] IRDC, 1982 in WHO 1994, reference 10.

[130] USDA 1987a in WHO 1994, reference 10.

[131] Bio/Dynamics, Inc., 1981a and Monsanto, 1984 in CA OEHHA 2007, reference 11.

[132] Monsanto, 1990 in CA OEHHA 2007, reference 11.

[133] Bio/Dynamics 1983 in CA OEHHA 2007, reference 11.

[134] Mladinic M, Berend S, Vrdoljak AL, *et al*. 2009. Evaluation of genome damage and its relation to oxidative stress induced by glyphosate in human lymphocytes in vitro. Environ Mol Mutagen. 50(9): 800-7.

[135] Lioi MB, Scarfi MR, Santoro A, et al. 1998. Cytogenetic damage and induction of pro-oxidant state in human lymphocytes exposed in vitro to glyphosate, vinclozolin, atrazine, and DPX-E9636. *Environ Mol Mutagen* 32(1): 39-46.

[136] Vigfusson NV, Vyse ER. 1980. The effect of the pesticides, Dexon, Captan and Roundup, on sister-chromatid exchanges in human lymphocytes in vitro. *Mutat Res* 79(1): 53-57.

[137] National Human Genome Research Institute, *DNA Microarray Technology*, http://www.genome.gov/10000533.

[138] Hokanson R, Fudge R, Chowdhary R, et al. 2007. Alteration of estrogen-regulated gene expression in human cells induced by the agricultural and horticultural herbicide glyphosate. *Hum Exp Toxicol* 26(9): 747-752.

[139] Martínez A, Reyes I, Reyes N. 2007. Cytotoxicity of the herbicide glyphosate in human peripheral blood mononuclear cells. *Biomedica* 27(4): 594-604. [Article in Spanish]

[140] Mañas F, Peralta L, Raviolo J, *et al*. 2009. Genotoxicity of AMPA, the environmental metabolite of glyphosate, assessed by the Comet assay and cytogenetic tests. Ecotoxicol Environ Saf. 72: 834-837.

[141] Bolognesi et al. 1997 in CA OEHHA 2007, reference 11.

[142] Lioi et al. Lioi et al. 1998a in CA OEHHA 2007, reference 11.

[143] Siviková K, Dianovsky J. 2006. Cytogenetic effect of technical glyphosate on cultivated bovine peripheral lymphocytes. *Int J Hyg Environ Health* 209(1): 15-20.

[144] Grisolia CK. 2002. A comparison between mouse and fish micronucleus test using cyclophosphamide, mitomycin C and various pesticides. *Mutat Res.* 518(2): 145-50.

[145] Prasad S, Srivastava S, Singh M, Shukla Y. 2009. Clastogenic effects of glyphosate in bone marrow cells of Swiss albino mice. *J Toxicol.* 2009:308985.

[146] NTP 1992 and Rank et al. 1993 in CA OEHHA 2007, reference 11.

[147] Heydens WF, Healy CE, Hotz KJ, *et al.* 2008. Genotoxic potential of glyphosate formulations: mode-of-action investigations. *J Agric Food Chem.* 56(4): 1517-23.

[148] Mañas F, Peralta L, Raviolo J, *et al.* 2009. Genotoxicity of AMPA, the environmental metabolite of glyphosate, assessed by the Comet assay and cytogenetic tests. *Ecotoxicol Environ Saf.* 72: 834-837.

[149] Malatesta M, Perdoni F, Santin G, *et al*. 2008. Hepatoma tissue culture (HTC) cells as a model for investigating the effects of low concentrations of herbicide on cell structure and function. *Toxicol In Vitro*. 22(8): 1853-60.

[150] Gehin A, Guillaume YC, Millet J, et al. 2005. Vitamins C and E reverse effect of herbicide-induced toxicity on human epidermal cells HaCaT: a biochemometric approach. *Int J Pharm* 288(2): 219-226.

[151] Elie-Caille C, Heu C, Guyon C, Nicod L. 2010. Morphological damages of a glyphosate-treated human keratinocyte cell line revealed by a micro- to nanoscale microscopic investigation. *Cell Biol Toxicol.* 26(4): 331-9.

[152] Lueken A, Juhl-Strauss U, Krieger G, et al. 2004. Synergistic DNA damage by oxidative stress (induced by $H_2O_2$) and nongenotoxic environmental chemicals in human fibroblasts. *Toxicol Lett* 147(1): 35-43.

[153] Horner, 1996a in USFS 2003, reference 5.

[154] Horner, 1996b in USFS 2003, reference 5.

[155] US EPA. *Series 870 Health Effects Test Guidelines*, US EPA Office of Pollution Prevention and Toxic Substances Harmonized Test Guidelines, US EPA, http://www.epa.gov/opptsfrs/publications/OPPTS_Harmonized/870_Health_Effects_Test_Guidelines/ Series/.

[156] Johnson 1997 in USFS 2003, reference 5.

[157] Williams et al., 2000 in USFS 2003, reference 5.

[158] Schiffman et al. 1995 in USFS 2003, reference 5.

[159] Astiz M, de Alaniz MJ, Marra CA. 2009. Effect of pesticides on cell survival in liver and brain rat tissues. *Ecotoxicol Environ Safety* 72(7): 2025-32.

[160] Nakashima K, Yoshimura T, Mori H, et al. 2002. Effects of pesticides on cytokines production by human peripheral blood mononuclear cells--fenitrothion and glyphosate. *Chudoku Kenkyu* 15(2): 159-165.

[161] Monroy CM, Cortes AC, Sicard DM, et al. 2005. Cytotoxicity and genotoxicity of human cells exposed in vitro to glyphosate. *Biomedica* 25(3): 335-345.

[162] Sullivan TP, Sullivan DS. 1979. The Effects of Glyphosate Herbicide on Food Preference and Consumption in Black-Tailed Deer**,** *Can J Zool* 57: 1406–1412.

[163] Newton M, Howard KM, Kelpsas BR, et al. 1984. Fate of glyphosate in an Oregon forest ecosystem. *J Agric Food Chem* 32: 1144–1151.

[164] Sullivan TP. 1990. Influence of forest herbicide on deer mouse and Oregon vole population dynamics. *J Wildl Manage* 54(4): 566–576. http://www.jstor.org/stable/3809350.

[165] Santillo et al., 1989b in WHO 1994, reference 10.

[166] D'Anieri et al., 1987 in WHO 1994, reference 10.

[167] Sullivan TP, Sullivan DS. 1981. Responses of a Deer Mouse Population to a Forest Herbicide Application: Reproduction, Growth, and Survival. *Can J Zool* 59: 1148–1154.

[168] Ritchie DC, Harestad AS, Archibald R. 1987. Glyphosate Treatment and Deer Mice in Clearcut and Forest. *Northwest Sci* 61(3): 199–202.

[169] Anthony and Morrison, 1985 in WHO 1994, reference 10.

[170] Palmer and Beaver 1997 in USFS 2003, reference 5.

[171] (a) Fink and Beaver 1975 in USFS 2003, reference 5.

(b) Fink et al. 1978 in USFS 2003, reference 5.

[172] Oliveira, A.G., L.F. Telles, R.A. Hess, G.A.B. Mahecha, and C.A. Oliveira. 2007. Effects of the Herbicide Roundup on the Epididymal Region of Drakes Anas platyrhynchos. *Reprod.Toxicol.* 23(2): 182-191.

[173] See Evan and Batty in USFS 2003, reference 5.

[174] (a) Batt, B.D.J., J.A. Black, and W.F. Cowan. 1980. The Effects of Glyphosate Herbicide on Chicken Egg Hatchability. *Can J Zool* 58:1940-1942.

(b) Hoffman and Albers in USFS 2003, reference 5.

[175] Johnson 1997 in USFS 2003, reference 5.

[176] Palmer and Krueger 2001a in USFS 2003, reference 5.

[177] Palmer and Krueger 2001b in USFS 2003, reference 5.

[178] Ahn, Y, J Cho, Y Kim, J Yoo, J Lee. 1997. Toxicity of the herbicide glufosinate-ammonium to *Tetranychus urticae* (Acari: Tetranychidae) under laboratory conditions. *Pest Sci* 51(1997): 455-461.

[179] Weppleman R. 1998b (unpublished) in USFS 2003, reference 5.

[180] Weppleman R. 1998a (unpublished) in USFS 2003, reference 5.

[181] (a) Haughton, A.J., J.R. Bell, N.D. Boatman, and A. Wilcox. 1999. The Effects of Different Rates of the Herbicide Glyphosate on Spiders in Arable Field Margins. *J Arachnol* 27(1):249-254.

(b) Haughton, A.J., J.R. Bell, A. Wilcox, and N.D. Boatman. 2001. The Effect of the Herbicide Glyphosate on Non-Target Spiders: Part I. Direct Effects on *Lepthyphantes tenuis* Under Laboratory Conditions. *Pest Manag Sci* 57:1033-1036.

(c) Haughton, A.J., J.R. Bell, N.D. Boatman, and A. Wilcox. 2001. The Effect of the Herbicide Glyphosate on Non-Target Spiders: Part II. Indirect Effects on Lepthyphantes tenuis in Field Margins. *Pest Manag Sci* 57: 1037-1042.

[182] Eijsackers H. 1991. Litter Fragmentation by Isopods as Affected by Herbicide Application. *Neth J Zool* 41(4):2 77-303.

[183] Samsoe-Petersen in USFS 2003, reference 5.

[184] Bramble et al. 1997 in USFS 2003, reference 5.

[185] Springett and Gray 1992 in USFS 2003, reference 5.

[186] Dalby, PR, GH Baker, SE Smith. 1995. Glyphosate 2,4-DB and dimethoate: effects on earthworm survival and growth. *Soil Biol. Biochem.* 27(12): 1661-1662.

[187] Mohammed 1995 in USFS 2003, reference 5.

[188] USDA/APHIS (Animal Plant Health Inspection Service) 1993 in USFS 2011, reference 5.

[189] USFS 2003 recommends the following studies for a discussion of how glyphosate chemically behaves in plants: Anthelme and Marigo 1998; Green et al. 1992; Hernandez et al. 1999; Hernandez et al. 2000; Hetherington et al. 1998; Jain et al. 2002; Pline et al. 2002; Uotila et al. 1995; Singh and Shaner 1998; Schonbrunn et al. 2001.

[190] Cedergreen N, Ritz C, Streibig JC. 2005. Improved empirical models describing hormesis. *Env Tox Chem* 24(12): 3166-3172.

[191] WSSA. *Home Page.* Weed Science Society of America. http://www.wssa.net/.

[192] Service, RF. 2007. Agbiotech: A growing threat down on the farm. *Science* 316(5828): 1114–1117.

[193] See Newmaster 1999 in USFS 2003, reference 5.

[194] (a) Bohn 1987 in USFS 2011, reference 5.

(b) Everett et al. 1996a in USFS 2011, reference 5.

(c) Willard 1996 in USFS 2011, reference 5.

[195] Al-Khatib, K and Peterson, D. 1999. Soybean (*Glycine max*) response to simulated drift from selected sulfonylurea herbicides, dicamba, glyphosate, and glufosinate. *Weed Tech* 13(2): 264-270.

[196] (a)Bhatti et al. 1997 in USFS 2003, reference 5.

(b) Fletcher et al. 1996 in USFS 2003, reference 5.

(c) Gilreath et al. 1996 in USFS 2003, reference 5.

[197] DeJong, FMW and HAU Haes. 2001. Development of a field bioassay for the side-effects of herbicides on vascular plants using *Brassica napus* and *Poa annua*. *Environ Toxicol* 16(5): 397-407.

[198] Marrs and Frost 1997 in USFS 2003, reference 5.

[199] Smith and Oehme 1992 in USFS 2003, reference 5.

[200] (a) Dick and Quinn 1995 in USFS 2003, reference 5.

(b) Dotson et al. 1996 in USFS 2003, reference 5.

[201] Bonnet, JL, F Bonnemoy, M Dusser, J Bohatier, 2007. Assessment of the potential toxicity of herbicides and their degradtiaon products to nontarget cells using two microorganisms, the bacteria *Vibrio fisheri* and the ciliate *Tetrahymena pyriformis*. *Envi Tox* 22: 78-91.

[202] Kremer RD, Means NE, Kim S. 2005. Glyphosate affects soybean root excudation and rhizosphere micro-organisms. *Int J Environ Anal Chem* 85(15): 1165–1174.

[203] Chakravarty and Sidhu 1987 in USFS 2003, reference 5.

[204] Issa 1998 in USFS 2003, reference 5.

[205] Cox 1999 in USFS 2003, reference 5.

[206] See Wan et al. 1998 in USFS 2003, reference 5.

[207] Pell et al. 1998 in USFS 2003, reference 5.

[208] Bromilow, RA, AA Evans, PH Nicholsm AD Todd, GG Briggs. 1996. The effect on soil fertility of repeated applications of pesticides over 20 years. *Pest Sci* 48(1): 63-72.

[209] Zablotowicz RM, Reddy KN. 2004. Impact of glyphosate on the *Bradyrhizobium japonicum* sypmbiosis with glyphosate resistant transgenic soybean: a minireview. *J. Environ. Qual.* 33: 825-831.

[210] Bellaloui N, Zablotowicz RM, Reddy KN, et al. 2008. Nitrogen metabolism and seed composition as influenced by glyphosate application in glyphosate-resistent soybean. *J Agri Food Chem.* 56(8): 2765-2772.

[211] See Wardle et al. 2001 in USFS 2003, reference 5.

[212] See Haney et al 2002, Hart and Brookes 1996, Laatikainen and Heinonen-Tanski 2002, and Nicholson and Hirsch 1998 in USFS 2003, reference 5.

[213] Descalzo RC, Punja ZK, Levesque CA, Rahe JE. 1998. Glyphosate treatment of bean seedlings causes short-term increases in Pythium populations and damping off potential in soils. *Appl Soil Ecol* 8: 25–33.

[214] Kawate MK, Colwell, SG, Ogg AG, et al. 1997. Effect of glyphosate-treated henbit (*Lamium amplexicaule)* and downy brome (*Bromus tectorum)* on *Fusarium solani* f. sp pisi and *Pythium utlimum*. *Weed Sci* 45(5): 739–743.

[215] Kassaby FY. 1985. Interaction of Four Herbicides with *Phytophthora cinnamomi*. *Australasian Plant Path* 14(2): 21–22.

[216] LSA Associates, Inc. 2011. Biological Resources Report: Mount Sutro Open Space Reserve ( No. LSA Project No. USF1001).

[217] Mitchell et al. 1987a in USFS 2011, reference 5.

[218] Wan et al. 1989 in USFS 2011, reference 5.

[219] UCSF Campus Planning. 2010. Notice of Preparation / Initial Study: University of California San Francisco Mount Sutro Management. http://campusplanning.ucsf.edu/pdf/Initial_Study_UCSF_Mt_Sutro_Mgmt.pdf.

[220] (a) Edginton, AN, PM Sheridan, GR Stephenson, DG Thompson, HJ Boermans. 2004. Comparative effects of pH and Vision herbicide on two life stages of four anuran amphibian species. *Environ Toxicol and Chem* 23(4): 815-822.

(b) Chen, CY, KM Hathaway, CL Folt. 2004. Multiple stress effects of Vision herbicide, pH, and food on zooplankton and larval amphibian species from forest wetlands. *Environ Toxicol and Chem* 23: 823-831.

[221] (a) Mitchell et al. 1987a, in USFS 2011, reference 5.

(b) Mann and Bidwell 1999, in USFS 2011, reference 5.

[222] Mann RM, Bidwell JR. The toxicity of glyphosate and several glyphosate formulations to four species of southwestern Australian frogs. *Arch. Environ. Contam. Toxicol.* 36 (1999): 193-199.

[223] See Perkins et al. 2000, in USFS 2003, reference 5.

[224] Relyea, R. 2005c. The lethal impact of Roundup and predatory stress on six species of North American . *Arch Environ Contam Toxicol* 48(2005): 351-357.

[225] Mann RM, Bidwell JR. The toxicity of glyphosate and several glyphosate formulations to four species of southwestern Australian frogs. *Arch. Environ. Contam. Toxicol.* 36 (1999): 193-199.

[226] Smith , GR. Effects of acute Exposure to a Commenrial Formulation of Glyphosate on the Tadpoles of Teo Species of Anurans. *Bull Environ Contam Toxicol.* 67 (2001): 483-488.

[227] Relyea R, Jones DK, 2009. The toxicity of roundup Original Max® to 13 species of larval amphibians. *Environ Tox Chem* 28:2004-2008.

[228] Howe, C.M., M. Berrill, B.D. Pauli, C.C. Helbing, K. Werry, and N. Veldhoen, 2004, Toxicity of Glyphosate-Based Pesticides to Four North American Frog Species, Environ.Toxicol.Chem. 23(8):1928-1938.

[229] Relyea, RA. 2004. Growth and survival of five amphibian species exposed to combinations of pesticides. *Environ Toxicol and Chem* 23: 1737-1742.

[230] Relyea, R. 2005a. The lethal impact of Roundup on aquatic and terrestrial amphibians. *Ecol Appl* 15(4): 1118-1124.

[231] Relyea R, Schoeppner N, Hoverman JT. 2005. Pesticides and amphibians: the importance of the community context. *Ecol Appl* 15(4): 1125-1134.

[232] Reylea, R. 2005d. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. *Ecol Appl* 15(2): 618-627.

[233] (a) Zaranyika, MF and G Nyandoro. 1993. Degradation of glyphosate in the aquatic environment: an enzymic kinetic model that takes into account microbial degradation of both free and colloidal (or sediment) particle adsorbed glyphosate. *J Ag Food Chem* 41: 838-842.

(b) Wang, N, JM Besser, DR Bucklet, JL Honegger, CG Ingersoll, BT Johnson, ML Kurtzweil, J MacGregor, MJ McKee. 2005. Influence of sediment on the fate and toxicity of a polyethoxylated tallowamine surfactant system (MON0818) in aquatic microcosms. *Chemosphere* 59: 545-551.

[234] Thompson DR, Solomon KJ, Wojtazsek BF, *et al*. 2006. Letter to the Editor on "The Impact of Insectidies and Herbicides on the Biodiversity of Aquatic Communities." *Ecol. Appl.* 16(5): 2022-2027.

[235] Wood TM. *Herbicide Use in the Management of Roadside Vegetation, Western Oregon, 1999-2000: Effects on the Water Quality of Nearby Streams.* USGS. Water-Resources Investigations Report 01-4065.

[236] Thompson DR, Wojtaszek BF, Staznik B, et al. 2004. Chemical and biomonitoring to assess potential acutre effects of Vision herbicide on native amphibian larvae in forest wetlands. *Environ Toxicol and Chem* 23(4): 843-849.

[237] (a) Trumbo J. 2005. An assessment of the hazard of a mixture of the herbicide Rodeo® and the non-ionic surfactant R-11® to aquatic invertebrates and larval amphibians. *California Fish and Game*. 91(1): 38-46.

(b) The Dose (and the Surfactant) Makes the Poison: Glyphosate formulations and amphibians *Cal-IPC News*. Vol. 14, No. 1, Spring 2006, http://www.cal-ipc.org/resources/news/pdf/Spring2006.pdf.

[238] Cole E, McComb W, Newton M, *et al*. Response of Amphibians to Clearcutting, Burning, and Glyphosate Application in the Oregon Coast Range. *J Wildlife Management* 61(3): 656-664.

[239] Vincent K 2009. The acute toxicity and sublethal effects of Aquamaster® and two Aquamaster® tank mixes. A report prepared for the Santa Clara Valley Water District by San Francisco State University.

[240] Alberdi et al. 1996 in USFS 2003, reference 5.

[241] Gardner SC, Grue CE. 1996. Effects of Rodeo and Garlon 3A on nontarget wetland species in central Wahington. *Environ Toxicol Chem* 15(4): 441-451.

[242] Hagg 1986 in USFS 2003, reference 5.

[243] Hildebrand 1980 in USFS 2003, reference 5.

[244] Simenstad CA, Cordell JR, Tear L, et al. 1996. Use of Rodeo and X-77 Spreader to control smooth cordgrass (*Spartina alterniflora*) in a southwestern Washington estuary: 1. Effects on benthic microflora and invertebrates. *Environ Toxicol Chem* 15(6): 969-978.

[245] Paveglio FL, Kilbride KM, Grue CE, CA Simenstad, KL Fresh. 1996. Use of Rodeo and X-77 Spreader to control smooth cordgrass (*Spartina alterniflora*) in a southwestern Washingotn estuary: 1. Environmental Fate. Environ. Tox. and Chem. 15(6): 961-968.

[246] Faust M, R Altenburger, W Boedeker, LH Grimme. 1994. Algal toxicity of binary combinations of pesticides. *Bull Environ Contam Toxicol* 53(1): 134-141.

[247] Austin AP, GE Harris, WP Lucey. 1991. Impact of an organophosphate herbicide (glyphosate) on periphyton communities developed in experimental streams. *Bull Environ Contam Toxicol* 47:29-35.

[248] Perschbacher PW, N Stone, GM Ludwig, CB Guy. Evaluation of effects of common aerially-applied soybean herbicides and propanil on the plankton communities of aquaculture ponds. *Aquaculture* 157(1997) 117-122.

[249] USFS 2003, reference 5, pp. 3b.1–3c.6.

[250] Faust M, R Altenburger, W Boedeker, LH Grimme. 1994. Algal toxicity of binary combinations of pesticides. *Bull Environ Contam Toxicol* 53(1): 134-141.

[251] CA DPR. California Department of Pesticide Regulation Pesticide Physical Properties Database. Personal communication with John Troiano.

[252] USDA. 2008. *Glyphosate.* Agricultural Research Service Pesticide List. http://www.ars.usda.gov/Services/docs.htm?docid=14147.

[253] Schuette J. 1998. *Environmental Fate of Glyphosate.* CA Department of Pesticide Regulation, November 1998, and references contained therein. http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/glyphos.pdf.

[254] Vereecken H. 2005. Mobility and leaching of glyphosate: A review. *Pest Manag Sci* 61: 1139–1151.

[255] OK Borggaard, AL Gimsing. Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: A review. *Pest Manag Sci,* 2008. 64: 441–456.

[256] RC Pessagno, RM Torres-Sanchez, M Afonso. Glyphosate behavior at soil and mineral-water interfaces. *Envi Poll,* 2008. Doi:10.1016/j.envpol.2007.12.025.

[257] (a) Giesy JP, Dobson S, Solomon KR. 2000. Ecotoxicological Risk Assessment for Roundup Herbicide. *Rev Environ Contam Toxicol* 167: 35–120.

(b) Newton et al. 1984 and Monsanto, 1990a in WHO 1994, reference 10.

[258] GS Siemering, JD Hayworth, BK Greenfield. Assessment of Potential Aquatic Herbicide Impacts to California Aquatic Ecosystems. *Arch Environ Contam Toxicol,* 2008. DOI 10.1007/s00244-008-9137-2

[259] Newton et al., 1984 in WHO 1994, reference 10.

[260] Torstensson et al., 1989 in WHO 1994, reference 10.

[261] Monsanto, 1972b in WHO 1994, reference 10.

[262] M Newton, LM Horner, JE Cowell, et al. Dissipation of glyphosate and aminomethyl phosphonic acid in North American forests, *J Agric Food Chem* 1994. 42: 1795–1802.

[263] W Kollman, R Segawa. *Interim report of the pesticide chemistry database, 1995*. Environmental Hazards Assessment Program. Department of Pesticide Regulation. http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/eh9504.pdf.

[264] Feng et al. 1990 in WHO 1994, reference 10.

[265] Goldsborough et al. 1993 in WHO 1994, reference 10.

[266] ExToxNet. 1996. *Glyphosate*. Extention Toxicology Network Pesticide Information Profiles. http://extoxnet.orst.edu/pips/glyphosa.htm.

[267] HSDB. 2006. National Library of Medicine, TOXNET. *Glyphosate*. Hazardous Substances Data Bank. Revised Aug. 2006. http://toxnet.nlm.nih.gov.

[268] Newton et al. 1984 in WHO 1994, reference 10.

[269] Monsanto 1990 in WHO 1994, reference 10.

[270] Goldsborough and Beck 1989 in WHO 1994, reference 10.

[271] PTRL East 1990 in WHO 1994, reference 10.

[272] Horner 1990 in reference 262.

[273] Roy et al. 1989 in WHO 1994, reference 10.

[274] PTRL East Inc. 1991 in WHO 1994, reference 10.

[275] Monsanto 1972; Rueppel et al. 1977 in WHO 1994, reference 10.

[276] Roy et al. 1989 in WHO 1994, reference 10.

[277] Feng and Thompson 1990 in WHO 1994, reference 10.

[278] Monsanto 1983 in WHO 1994, reference 10.

[279] Hwang H-M, Young TM. 2011. *Final Report: Environmental decay of glyphosate in broom-infested Mt. Tamalpais soils and its transport through stormwater runoff and soil column infiltration.* Submitted to Marin Municipal Water District, April 19, 2011. Obtained from Janet Klein at MMWD.

[280] Carlisle SM, Trevors JT. 1988. Glyphosate in the Environment. *Water Air Soil Poll* 39: 409–420.

[281] AL Gimsing, OK Borggaard, OS Jacobsen, et al. Chemical and microbiological soil characteristics controlling glyphosate mineralization in Danish surface soils. Appl Soil Ecol 2004. 27:233–242.

[282] Chang F-C, Simcik MF, Capel PD. 2011. Occurrence and fate of the herbicide glyphosate and its degradate aminomethylphosphonic acid in the atmosphere. *Envi Tox Chem* 30(3):548–555.

[283] JN Smith, RC Martin, RG Croix, Levels of the herbicide glyphosate in well water. Bull Envi Contam Toxicol 1996. 57:759–65. http://www.springerlink.com/content/cmncreempr5l4pdf/?p=7e8cf8e87fd34615bdfc1af39b78c4fc&pi=0.

[284] Kjaer J, Ullum M, Olsen P, et al. *The Danish Pesticide Leaching Assessment Programme: Monitoring Results May 1999–June 2002. Third Report.* 2003. Geological Survey of Denmark and Greenland. Danish Institute of Agricultural Sciences, National Environmental Research Institute, Denmark.

[285] Shipitalo MJ, Owens LB. 2006. Tillage system, application rate, and extreme even effects on herbicide losses in surface runoff. *J Envi Qual* 35(6): 2186–94.

[286] Glyphosate. Environmental Health Criteria 159, 1994. World Health Organization International Programme on Chemical Safety, http://www.inchem.org/documents/ehc/ehc/ehc159.htm.

[287] (a) Monsanto. 2005. *Backgrounder: No Restriction of Autumn Use of Glyphosate in Denmark*. Monsanto. April 2005. http://www.monsanto.com/monsanto/content/products/productivity/roundup/denmark_bkg_05.pdf.

(b) Monsanto. 2003. *Backgrounder: Glyphosate and Water Quality*. Monsanto. November 2003. http://www.monsanto.com/monsanto/content/products/productivity/roundup/gly_water_bkg.pdf.

[288] Coupe RH, Kalkhoff SJ, Capel PD, Gregoire C. 2011. Fate and transport of glyphosate and aminomethylphosphonic acid in surface waters of agricultural basins. *Pest Management Science.* DOI 10.1002/ps.2212.

[289] Means NE, Kremer RJ, Ramsier C. 2007. Effects of glyphosate and foliar amendments on activity of microorganisms in the soybean rhizosphere. *J Environ Sci Health Part B* 42: 125–132, and references therein.

[290] Battaglin, WA, DW Kolpin, EA Scribner, KM Kuivila, MW Sandstrom. 2005. Glyphosate, other herbicides and transformation products in Midwestern streams, 2002. *J Amer Water Res Assoc* 41: 323-332.

[291] Battaglin WA, Rice KC, Focazio MJ, Salmons S, Barry RX. 2009. The occurrence of glyphosate, atrazine, and other pesticides in vernal pools and adjacent streams in Washington, DC, Maryland, Iowa, and Wyoming, 2005–2006. *Environ Monit Assess* 155:281–307 DOI 10.1007/s10661-008-0435-y.

[292] Baker NT, Stone WW, Wilson JT, Meyer MT. 2006. Occurrence and Transport of Agricultural Chemicals in Leary Weber Ditch Basin, Hancock County, Indiana, 2003–04. US Geological Survey Scientific Investigations Report 2006–5251. pubs.usgs.gov/sir/2006/5251/pdf/sir20065251_web.pdf.

[293] Lathrop TR, 2006. *Environmental Setting of the Sugar Creek and Leary Weber Ditch Basins, Indiana, 2002–04.* US Geological Survey,, Report 2006-5170.

[294] Peruzzo PJ, Porta AA, Ronco AE, Levels of glyphosate in surface waters, sediments and soils associated with direct sowing soybean cultivation in north pampasic region of Argentina. Envi Poll, 2008. doi:10.1016/j.envpol.2008.01.015.

[295] JStruger J, D Thompson, B Staznik et al. Occurrence of glyphosate in surface waters of southern Ontario. Bull Environ Contam Toxicol, 2008. doi:10.1007/s00128-008-9373-1.

[296] Bakke D, 2001. A review and assessment of the results of water monitoring for herbicide residues for the years 1991 to 1999: USFS Region Five. Proceedings - Forest Vegetation Management Conference (22nd): 42-65. Obtained from D. Bakke.

[297] Monsanto. 2005. Aquamaster MSDS. Feb 3, 2005. http://www.cdms.net/LabelsMsds/LMDefault.aspx?pd=4742.

[298] Monsanto. 2009. Aquamaster: Complete Directions for Use in Aquatic and Other Non-crop Sites. http://www.agrian.com/pdfs/AquaMaster_Herbicide_Label4a.pdf.

[299] US EPA rates acute product hazards on a scale of I to IV, with I the most-toxic and IV the least-toxic category. See reference 300.

[300] Labeling requirements for Pesticides and Devices. Code of Federal Regulations, Title 40, Vol. 16, Part 156. http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi?TITLE=40&PART=156&SECTION=10&YEAR=2000&TYPE=TEXT.

[301] Hirsch and Augustin 1987 in USFS 2003, reference 5.

[302] UCSF Campus Planning. 2010. Notice of Preparation / Initial Study: University of California San Francisco Mount Sutro Management. http://campusplanning.ucsf.edu/pdf/Initial_Study_UCSF_Mt_Sutro_Mgmt.pdf.

[303] USFS. 2010. Herbicide Risk Assessment Worksheets. http://www.fs.fed.us/foresthealth/pesticide/worksheets.shtml.

[304] SERA. 2007. Preparation of Environmental Documentation and Risk Assessments for the USDA/Forest Service. Syracuse Environmental Research Associates, Inc. January 21, 2007, Fayetteville, NY. http://www.sera-inc.com/images/SERA_MD_2007-01a_Risk_Assessment_Methods_for_Forest_Service.pdf.

USFS. 2004. *Clopyralid Human Health and Ecological Risk Assessment Final Report.* 2004. Prepared for the US Forest Service by Syracuse Environmental Research Associates, Inc. Report No. SERA TR 04-43-17-03c. December 4, 2004. http://www.fs.fed.us/foresthealth/pesticide/risk.shtml.

[305] (a) Wester *et al.* 1991 in USFS 2003, reference 5.

(b) Wester *et al.* 1996 in USFS 2003, reference 5.

[306] Carmichael 1989 in USFS 2003, reference 5.

[307] (a) Feng *et al.* 1990 in USFS 2003, reference 5.

(b) Kreutzweiger *et al.* 1989 in USFS 2003, reference 5.

(c) Newton *et al.* 1984 in USFS 2003, reference 5.

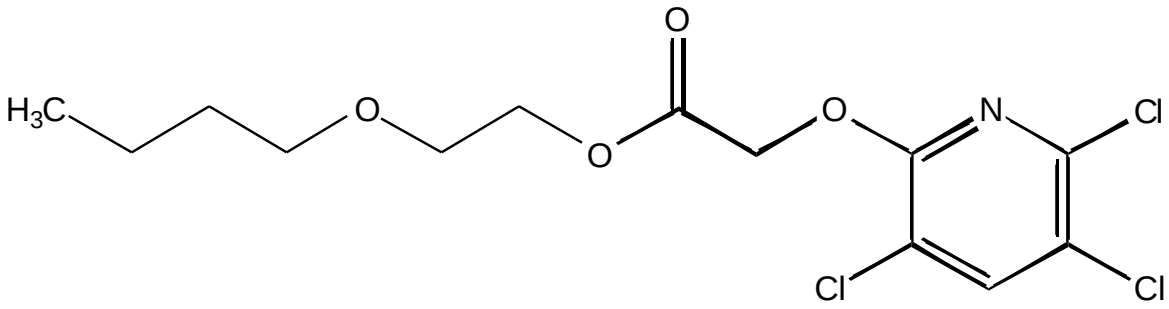
(d) Neary and Michael (1996) in USFS 2003, reference 5.

[308] UCSF. 2001. *Mount Sutro Open Space Reserve Management Plan, September 2001*. University of California, San Francisco. September 2001.campusplanning.ucsf.edu/pdf/Mount_Sutro_Reserve_Plan.pdf.

[309] USFS. 2011. Appendices to *Glyphosate Human Health and Ecological Risk Assessment Final Report* (SERA TR-052-22-03b), Appendices. http://www.fs.fed.us/foresthealth/pesticide/pdfs/Glyphosate_SERA_TR-052-22-03a-App.pdf.

[310] USFS. 2011. *Glyphosate Human Health and Ecological Risk Assessment Final Report* (SERA TR-052-22-03b). http://www.fs.fed.us/foresthealth/pesticide/pdfs/Glyphosate_SERA_TR-052-22-03b.pdf.

# Chapter 4 — Triclopyr



# 4 Table of Contents — Triclopyr

**4.1 INTRODUCTION ..... 4-5**

**4.2 TRICLOPYR TOXICITY TO HUMANS AND LEVELS OF CONCERN ..... 4-6**

4.2.1 HEALTH EFFECTS ..... 4-6
4.2.2 LEVELS OF CONCERN FOR HUMANS ..... 4-6
4.2.3 ROUTES OF EXPOSURE ..... 4-7
4.2.4 BIOMONITORING STUDIES ..... 4-9
4.2.5 PESTICIDE ILLNESS REPORTS ..... 4-11

**4.3 TRICLOPYR TOXICITY TO ANIMALS AND PLANTS AND LEVELS OF CONCERN ..... 4-11**

4.3.1 MAMMALS ..... 4-12
4.3.1.A Metabolism and Pharmacokinetics of Triclopyr ..... 4-13
4.3.1.B Acute Toxicity of Triclopyr ..... 4-14
4.3.1.C Sub-Chronic Toxicity of Triclopyr ..... 4-15
4.3.1.D Chronic Toxicity and Carcinogenicity of Triclopyr ..... 4-16
4.3.1.E Reproductive and Developmental Toxicity of Triclopyr ..... 4-23
4.3.1.F Neurotoxicity ..... 4-27
4.3.1.G Immunotoxicity ..... 4-27
4.3.1.H Endocrine Disruption ..... 4-28
4.3.1.I Effects on Mammalian Wildlife ..... 4-28
4.3.1.J Size Differences in Mammalian Response to Triclopyr ..... 4-28
4.3.1.K Levels of Concern for Mammals ..... 4-29
4.3.2 OTHER TERRESTRIAL ORGANISMS ..... 4-30
4.3.2.A Birds ..... 4-30
4.3.2.B Terrestrial Invertebrates ..... 4-31
4.3.2.C Terrestrial Plants ..... 4-31
4.3.2.D Soil Microbes ..... 4-32
4.3.3 AQUATIC ORGANISMS ..... 4-33
4.3.3.A Fish ..... 4-33
4.3.3.B Amphibians ..... 4-34
4.3.3.C Aquatic Invertebrates ..... 4-35
4.3.3.D Aquatic Plants ..... 4-38
4.3.4 DATA GAPS ..... 4-39

**4.4 ENVIRONMENTAL FATE OF TRICLOPYR ..... 4-44**

4.4.1 OVERVIEW ..... 4-44
4.4.2 WATER SOLUBILITY AND SOIL BINDING OF TRICLOPYR ..... 4-45
4.4.3 PERSISTENCE OF TRICLOPYR ..... 4-45
4.4.3.A Microbial Degradation ..... 4-48
4.4.3.B Transport by Air ..... 4-48
4.4.3.C Transport by Water ..... 4-49
4.4.3.D Uptake by Plants ..... 4-49
4.4.3.E Field Studies on the Environmental Fate of Triclopyr ..... 4-50
4.4.4 GARLON 4 ULTRA PRODUCT PROFILE ..... 4-52

**4.5 EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION FOR TRICLOPYR ..... 4-52**

4.5.1 CHEMICAL-SPECIFIC EXPOSURE PARAMETERS ..... 4-54
4.5.2 APPLICATION METHODS FOR TRICLOPYR ..... 4-55
4.5.3 WATER CONTAMINATION ESTIMATES ..... 4-56
4.5.4 RISKS TO HUMANS ..... 4-63

4.5.4.A Workers ..... 4-63
4.5.4.B General Public ..... 4-69
4.5.5 RISKS TO WILDLIFE ..... 4-76
4.5.5.A Terrestrial Wildlife ..... 4-76
4.5.5.A Terrestrial Plants ..... 4-93
4.5.5.B Aquatic Wildlife ..... 4-93
**REFERENCES FOR CHAPTER 4 ..... 4-115**

# Table of Tables

Table 4-1: Triclopyr-related Illnesses Reported by California Physicians to the Pesticide Incident Surveillance Program (PISP) 1987 to 2004 ..... 4-11
Table 4-2: Acute Toxicity of Triclopyr in Experimental Animals ..... 4-14
Table 4-3: Dermal Toxicity of Triclopyr to Mammals ..... 4-15
Table 4-4: Sub-chronic Toxicity of Triclopyr to Mammals ..... 4-19
Table 4-5: Chronic Toxicity of Triclopyr to Mammals ..... 4-22
Table 4-6: Reproductive and Developmental Toxicity of Triclopyr to Mammals ..... 4-24
Table 4-7: Comparison of Triclopyr and TCP TRVs Used in USFS and Mount Sutro Risk Assessments for Terrestrial Organisms ..... 4-40
Table 4-8: Comparison of Triclopyr and TCP TRVs Used in USFS and Mount Sutro Risk Assessments for Aquatic Organisms ..... 4-42
Table 4-9: Chemical and Physical Properties of Triclopyr ..... 4-45
Table 4-10: Half-Life of Triclopyr Acid, Butoxyethyl Ester (BEE), and Triethylamine Salt (TEA) ..... 4-46
Table 4-11: Triclopyr-Specific Exposure Parameters ..... 4-55
Table 4-12: Application Rate and Application Volume Model Inputs for Garlon IV Ultra ..... 4-55
Table 4-13: Calculated Triclopyr Concentrations for Water Contamination Scenarios on Mount Sutro ..... 4-58
Table 4-14: Percent of Herbicide Lost as a Function of Annual Rainfall and Soil Type ..... 4-59
Table 4-15: Triclopyr BEE Concentrations at Wastewater Treatment Plants During the 5-Year Storm ..... 4-60
Table 4-16: Triclopyr Acid Concentrations at Wastewater Treatment Plants During the 5-Year Storm ..... 4-61
Table 4-17: TCP Concentrations at Wastewater Treatment Plants During the 5-Year Storm ..... 4-62
Table 4-18: Estimated Risks for Workers from Triclopyr BEE Exposures ..... 4-67
Table 4-19: Estimated Risks for the General Public from Triclopyr BEE Accidental Acute Dermal Exposures ..... 4-71
Table 4-20: Estimated Risks for Humans Drinking Triclopyr-Contaminated Water ..... 4-73
Table 4-21: Estimated Risks for Terrestrial Wildlife Exposed to Triclopyr BEE through Direct Sprays and Food Consumption ..... 4-79
Table 4-22: Estimated Risks for Small Mammals Drinking Triclopyr-Contaminated Water ..... 4-81
Table 4-23: Estimated Risks for Carnivorous Mammals Drinking Triclopyr-Contaminated Water ..... 4-84
Table 4-24: Estimated Risks for Small Birds Drinking Triclopyr-Contaminated Water ..... 4-87
Table 4-25: Estimated Risks for Large Birds Drinking Triclopyr-Contaminated Water ..... 4-90
Table 4-26: Estimated Risks for Sensitive Amphibians Exposed to Triclopyr-Contaminated Water ..... 4-99
Table 4-27: Estimated Risks for Sensitive Fish Exposed to Triclopyr at Wastewater Treatment Plant Outfalls ..... 4-102
Table 4-28: Estimated Risks for Sensitive Aquatic Invertebrates Exposed to Triclopyr-Contaminated Water ..... 4-105
Table 4-29: Estimated Risks for Aquatic Plants Exposed to Triclopyr-Contaminated Water ..... 4-110

## 4.1 Introduction

Triclopyr is a pyridinecarboxylic acid herbicide that is selective for broadleaf plants and is not toxic to grasses and conifers. It is used for controlling unwanted woody plants, annual and perennial broadleaf weeds in forest, and on non-crop areas including industrial sites, rights-of-way (i.e., electrical power lines, communication lines, pipelines, roadsides, railroads), fence rows, non-irrigation ditch banks, and around farm buildings. Triclopyr kills plants by mimicking auxins—plant growth hormones—and damages the plant by causing uncontrolled growth.

There are two forms of triclopyr currently registered for use in the US—the triethylamine (TEA) salt and the butoxyethyl ester (BEE). Triclopyr TEA was first registered in 1979 and triclopyr BEE was first registered in 1980. Although triclopyr has been registered almost as long as glyphosate, it is used much less extensively—two to four million pounds annually were estimated in 2007.[1] Triclopyr is used in residential settings on turf, on golf courses, in agriculture and in forestry. In California, where more recent use data are available, reported use of triclopyr salts and esters was 125,226 lbs in 2009;[2] in the same year, reported sales of triclopyr-containing products (includes non-commercial use) was 276,681 lbs.[3] Triclopyr is currently registered for use in the European Union[4] and was re-evaluated by US EPA most recently in 2006.

Garlon 4 Ultra, containing the active ingredient triclopyr BEE and a methylated seed oil adjuvant, was designated as an herbicide for use as a cut-stump treatment for the Mount Sutro project. Most toxicity studies available in the literature were done with either Garlon 3 (containing triclopyr TEA salt as the active ingredient and ethanol, triethylamine and ethylene diamine tetraacetic acid (EDTA) as other ingredients) or Garlon 4 (containing triclopyr BEE and kerosene as an adjuvant).[5] There are substantial differences in acute toxicity between the BEE and TEA derivatives, with BEE much more toxic in aquatic settings.

The effect of changing the adjuvant from kerosene in Garlon 4 to methylated seed oil in Garlon 4 Ultra is unknown—there are no toxicity studies available for Garlon 4 Ultra. However, the toxicity of the two adjuvants alone is on the same order of magnitude: the mammalian $LC_{50}$ for kerosene is 16,000–23,000 mg/kg,[6] and the mammalian $LC_{50}$ for methylated seed oil has been determined to be greater than 2,000 up to 17,000 mg/kg, depending on the length of the fatty acid carbon chain.[7] The USFS notes that the toxicity of kerosene to aquatic species is approximately 100–1,000 fold less than triclopyr BEE, with $LC_{50}$ values of 200–3,000 mg/L, which suggests that the acute aquatic toxicity of Garlon 4 is dominated by triclopyr BEE. Methylated seed oil adjuvants such as the one in Garlon 4 Ultra have low acute aquatic toxicity (53.1 mg/L for bluegill sunfish, *Lepomis macrochirus*[8]), similar to that for kerosene (9.5 mg/L for guppies, *Poecilia reticulate*[9]). Thus, we would not anticipate that a change in adjuvant would significantly alter the acute aquatic toxicity of the product, unless synergistic effects come into play. Changes in chronic toxicity are difficult to predict, but chronic exposure is not anticipated for either of these two adjuvants because they degrade rapidly in the environment.

This chapter focuses on the human toxicity, ecotoxicity, and environmental fate of triclopyr, drawing from the United States Forest Service's Human Health and Ecological Risk Assessment of Triclopyr, 2003[6] (USFS 2011), US EPA's Re-registration Decision 1998[10] (RED 1998), EPA's pesticide tolerance decision in the Federal Register in 2002 (EPA 2002),[11] the 2009

California Red-legged Frog Effects Determination,[12]and the EPA Ecotox database[13] (Terretox for the terrestrial database and AQUIRE for the aquatic database). The chapter focuses on the toxicity of triclopyr BEE. An extensive survey of the peer-reviewed literature was conducted to find additional research results not available in these documents.

## *4.2 Triclopyr Toxicity to Humans and Levels of Concern*

The active pesticide ingredient in Garlon 4 Ultra is triclopyr butoxyethyl ester (triclopyr BEE), which undergoes hydrolysis in the human body to form triclopyr acid. The data are sparse on potential acute and chronic human health effects from exposure to triclopyr. Most of the human studies available involve monitoring of a small number of male forestry workers exposed to triclopyr for short durations, from six days to several months. Most of the toxicity data used by US EPA for assessing risk to humans is from animal studies, which are summarized in Section 4.3.

The most common route of exposure to triclopyr for humans is absorption through the skin. Inhalation exposure to triclopyr is much lower than dermal exposure due to the low volatility of triclopyr BEE.

There are no case reports of acute toxic effects of triclopyr exposure; nor are there any incidents reported in either TESS or SENSOR pesticide illness surveillance systems. The California Pesticide Incident Surveillance Program (PISP) reported 17 cases over a ten-year period, all involving irritant effects to the eyes, skin, or upper respiratory system (Table 4-1). The most important immediate concern to workers is skin and eye irritation, which can be mitigated with protective clothing and good work practices.

There are no epidemiological studies of acute or potential chronic health effects related to triclopyr exposure. One of the biomonitoring studies discussed below which used a mathematical model to estimate absorbed dose of triclopyr found that some workers had exceeded the recommended EPA reference dose.

### 4.2.1 Health Effects

There are no case reports or epidemiological studies related to human triclopyr exposure. See Section 4.3.1 for animal data on chronic health effects.

### 4.2.2 Levels of Concern for Humans

For the Mount Sutro risk assessment, we used the acute triclopyr Reference Dose (RfD) for women of childbearing age (0.05 mg/kg-day) and for the general population (1.0 mg/kg-day). For the scenario of drinking water contaminated with long-term runoff, we used the chronic Population Adjusted Dose (PAD) of 0.012 mg/kg-day developed by EPA for the triclopyr degradation product TCP.

The acute EPA RfD of 1.0 mg/kg-day for triclopyr is based on a NOAEL for a developmental toxicity study in rats of 100 mg/kg-day, where unspecified “clinical signs” were observed on gestation day seven at the next highest dose of 300 mg/kg-day. This NOAEL was divided by both intra- and inter-species factors of 10 to give a value of 1.0 mg/kg-day for adult males. The acute RfD for women of childbearing age is 0.05 mg/kg-day, based on a multi-generation

reproductive toxicity study in rats. The NOAEL is 5 mg/kg-day, based on birth defects including exencephaly (brain outside the skull) and ablepharia (no eyelids) at the next higher dose of 25 mg/kg-day. The chronic EPA RfD is based on a NOAEL of 5 mg/kg-day for parental/systemic toxicity in a two-generation study in rats based on the observation of proximal tubular degeneration of the kidneys of P1 and P2 parental rats at the next highest dose of 25 mg/kg/day, adjusted with both intra- and inter-species factors of 10 to give an RfD of 0.05 mg/kg-day. In EPA's 2002 tolerance notice for triclopyr, the chronic RfD is also applied to short- and intermediate-term exposure times of one to six months.[11]

Population adjusted doses (PADs) for TCP, the primary degradation product of triclopyr, were developed by US EPA in the 2002 re-evaluation of triclopyr tolerances.[11, 14] The acute PAD for women of childbearing age is 0.025 mg/kg-day, based on a NOAEL of 25 mg/kg-day for increased incidence of hydrocephaly and dilated ventricles in rabbits seen at the next higher dose of 100 mg/kg-day. The NOAEL was adjusted with the intra- and inter-species uncertainty factors of 10, as well as an additional Food Quality Protection Act (FQPA) factor of 10 to protect vulnerable populations. The chronic PAD is 0.012 mg/kg-day, based on a NOAEL of 12 mg/kg-day observed in a 1-year dog study in which alterations in clinical chemistry levels were observed at the next higher dose of 48 mg/kg-day. EPA adjusted the NOAEL with the intra- and inter-species uncertainty factors of 10, as well as an additional FQPA factor of 10 to protect vulnerable populations.

### 4.2.3 Routes of Exposure

Potential human exposure to triclopyr is through skin absorption, inhalation, ingestion, or the eye. Triclopyr BEE is of low acute toxicity to humans and is placed by the US Environmental Protection Agency (EPA) in Category III slightly toxic. The oral reference dose (RfD) determined by the EPA that is not likely to cause harmful effects during a lifetime for both adults and children is 0.05 mg/kg-day and the acute RfD is 1.0 mg/kg-day.[10]

**Dermal:** The skin is the major route of exposure for triclopyr, where it is slowly absorbed. In the only study in which triclopyr BEE was applied to the skin of humans, it was found to be excreted in the urine in decreasing amounts for four days. [15]

In a study of five male human volunteers, 0.65-1.10 mL of undiluted Garlon 4 (equivalent to 5.0 mg/kg body weight of triclopyr BEE) was applied to the left forearm (mean 259 mg), and wiped off with a paper towel after eight hours.[15] Blood was drawn 11 times from 0.5 hour to 72 hours after the application, and urine was collected over the next 96 hours. Triclopyr was detected in the blood at three hours after application. Peak blood levels were found at 12 hours, and triclopyr was undetectable at 72 hours. The highest blood level found in any individual was 0.08 µg/mL. An average of 1.37 percent of the applied dose was excreted in the urine. Absorption through the skin was slow with a half-time of 16 hours. The largest amount excreted in the urine occurred in the first 12-24 hour period (0.56-2.5 mg) and declined to a measurable but low level by 84–96 hours. The author's fit the data to a one-compartment pharmacokinetic model, which corrected for the 81.7 percent recovery found after oral administration, and concluded that an average of 1.65 percent of the dermal dose was absorbed.

In a study comparing rat and human skin absorption of xenobiotics, 1.7 cm diameter full thickness samples of rat skin and normal human female breast skin obtained from surgery were placed in diffusion cells and allowed to equilibrate for about 30 minutes.[16] Skin tissue in 'flow-through' diffusion cells closely resembles the true skin barrier because of the continuous flow of a receptor fluid across the underside of the skin that mimics dermal blood flow, and maintains skin viability. Carbon-14-labeled triclopyr BEE (> 99 percent pure) was applied to the skin in the amount of 15.0 mg/cm$^2$ and then occluded or left open to the atmosphere. Receptor fluid was collected for up to 72 hr, scintillation fluid was added, and levels of $^{14}$C radioactivity remaining in the skin determined.

The absorption capacity through unoccluded human skin for triclopyr BEE was much less than for the rat. The recovery of radioactivity at 72 hours was 5.1 percent in human skin versus 63 percent in rat skin, that is, 12 times more triclopyr BEE penetrated the skin of the rat. A much larger amount was left on the surface of human skin (48.4 percent) than on rat skin (12.3 percent), and recovered in the diffusion cells of human skin (41.1 percent) versus rat cells (8.6 percent), both of which indicate greater absorption in the rat.

The skin is known to contain significant xenobiotic-metabolizing activity, and some degree of metabolic conversion of topically applied compounds will occur during percutaneous absorption. Such cutaneous metabolic events may be an important determinant of systemic exposure, and since the skin contains considerable esterase activity, it is likely that the ester, triclopyr BEE, may undergo a degree of hydrolysis during absorption, resulting in the formation of triclopyr acid. Triclopyr TEA will also rapidly dissociate to form triclopyr acid.

**Inhalation:** Triclopyr acid has a low vapor pressure of $<1 \times 10^{-8}$ mm Hg (25°C), and triclopyr BEE has a moderately low vapor pressure of $3.6 \times 10^{-6}$ mm Hg (25°C). Potential exposure via this route is low as discussed in the biomonitoring studies below. No Occupational Health and Safety Administration (OSHA) permissible exposure limit (PEL) or ACGIH threshold limit value (TLV) in air have been set for triclopyr.

**Ingestion:** Orally administered triclopyr is rapidly absorbed and excreted, with most excreted unchanged in the urine. Six male volunteers were administered an oral dose of 0.1 mg/kg body weight (one tenth the adult male, acute RfD) as a solution of 0.098 mg triclopyr per mL of apple juice. Three weeks later a higher oral dose of 0.5 mg/kg body weight (half the adult male acute RfD) was administered at 0.176 mg/mL. Blood was drawn at 0.5, 1, 2, 3, 4, 6, 8, 12, 24 and 48 hours after dosing. Urine was collected 13 hours prior to dosing, 0-6 and 6-12 hours post dosing, and then every 12-hour period for the next 60 hours.

Triclopyr was detected in the blood at 0.5 hours at both dose levels. Peak blood levels at two hours were 0.27 µg/mL at the lower dose and 1.44 µg/mL at the higher dose. Triclopyr was not detected in the blood 24 hours after the lower dose and 48 hours after the higher dose. Most of the triclopyr was excreted unchanged in the urine (81.7 percent). The potential major metabolite of triclopyr—3,5,6-trichloropyridinol—was less than 0.5 percent of the total dose in pooled 24-hour urine samples from the higher dose study. This suggests that very little triclopyr is metabolized in humans.[15]

### 4.2.4 Biomonitoring Studies

There are five biomonitoring studies of forest workers applying triclopyr, involving a total of 36 forest workers over a period of two to ten days, one study involving 10 forestry workers applying a tank mixture of 2,4-D and triclopyr for six days in northern California, and another study of three roadside spray workers followed for three seasons. The workers were monitored as part of their usual workday. All of the workers' urine was collected for the duration of the study. Triclopyr was excreted unchanged in the urine and detected at levels in the part per billion (ppb) range from both inhalation and dermal exposure. Doses of triclopyr in milligrams per kilogram of body weight exceeded RfDs for some workers, with higher exposure noted for those who did not wear gloves.

In general, the estimated absorbed dose was lower in backpack sprayers than boom type sprayers, depending on foliage contact (whether working with stumps or trees, and the height of the trees). There was great variability among individual workers depending on the use of protective clothing, gloves and work habits.

In an inhalation study measuring triclopyr BEE, absorption was very low, accounting for less than two percent of the estimated daily-absorbed dose compared to the estimate of 98 percent from dermal absorption.

The amounts found in the urine are a measure of recent exposure at the time of sampling and cannot be used to ascertain or predict past or future exposures over time. Testing biological samples for triclopyr is not available in standard medical care facilities or laboratories.

**2011:** Zhang *et al*. (2011) investigated exposure to 2,4-D and triclopyr (Garlon 4™) following six days of concurrent application of a tank mixture in a conifer release program by a 10-member crew in northern California in 2002.[17] Absorbed doses of 2,4-D and triclopyr were calculated based the statistical curve fitting of residue levels on the workers' clothing against measured urinary ester levels. Doses based on the accumulation of herbicide residues on clothing averaged 42.6 and 8.0 μg a.e./kg-day for 2,4-D and triclopyr, respectively. Daily doses of the herbicides following six consecutive days of concurrent urine collections averaged 11.0 and 18.9 μg a.e./kg-day for 2,4-D and triclopyr esters, respectively. Based on these results, total dose estimates of 17.1 and 29.3 μg a.e./kg-day for 2,4-D and triclopyr, respectively were calculated. For triclopyr, the average dose was 58% of the acute female RfD. The authors concluded that biomonitoring was a far superior method of assessing exposures, with passive dosimetry of triclopyr underestimating the absorbed dose by factors of two- to four-fold.

**2001:** The urine of forestry workers applying Garlon 4 in Quebec, Canada was monitored on the final day of a five-day work week.[18] Eight workers were applying dilute Garlon 4 (20 percent Garlon 4 and 80 percent mineral oil) with a backpack unit directly on the stumps of recently cut trees, and two workers were applying dilute Garlon 4 (12.6 liters of Garlon 4 mixed in 1,800 liters of water) under high voltage transmission lines from a tractor-mounted boom.

The workers collected all their urine from the start of their workday until the first urination the following morning. The average amount of triclopyr found in urine was 0.0564 mg/kg of body weight—from 1.04 to 12.98 mg/day in the eight backpack sprayers, and 3.61 to 5.97 mg/day in

the two boom sprayers. A mathematical model was developed to estimate the absorbed dose from triclopyr exposure using the amount excreted in the urine by each worker. The mean estimated daily absorbed dose based on a simulated fraction recovered in the urine was 11.92 mg (34.9%) in the backpack sprayers and 14.4 mg (31.4%) in the boom sprayers.

This dose would result in a cumulative urinary excretion of triclopyr equal to 1.45 mg/kg b.w. for a 24 h collection, 2.63 mg/kg b.w. for a 48 h collection and 2.83 mg/kg b.w. for a 72 h collection. Comparisons between the estimated daily doses absorbed by the workers in this study and the RfD show that there is a potential health risk for these workers under the current conditions. Since there is no observed effect in humans exposed to triclopyr, there is no proof that the NOEL established for rats corresponds to a safe dose for humans. One worker was above the RfD.

**1995:** A two day biomonitoring study of skin and inhalation exposure to Garlon 4 was conducted in California in 1995 of ten forestry workers applying Garlon 4 (containing 61.6% (5.56 lb/gal) of the formulated product) using backpack sprayers and spray wands).[19] Twenty-four-hour urine samples were collected to estimate absorbed dose.

Dermal exposure was monitored by measuring residues on work clothing worn next to the skin (long sleeved cotton T-shirts and knee-length socks) and wipe samples of the hand, face, and neck. Upper body exposure accounted for 45 percent of exposure, legs 33 percent, hands 19 percent and face/neck three percent. Mean measured dermal triclopyr exposure of 18.67 mg per person accounted for 98 percent of the estimated daily absorbed dose for the two days.

Triclopyr has a low vapor pressure (0.2 mPa at 25 °C), and inhalation is not a major route of exposure. Comparing the inhalation exposures reported below to the worker exposures reported above shows that inhalation accounts for approximately 0.3-5% of a workers' measured dose. Inhalation doses of triclopyr BEE measured using personal air monitors ranged from 32.6 to 71.7 μg per day, accounting for 1.89 percent of the mean daily absorbed dose for the two days. Although air concentrations of triclopyr are below the human RfD, triclopyr air concentrations may still damage plants.

Twenty-four hour urine samples were collected to obtain an estimate of absorbed dose (EAD). Overall EAD from urinary triclopyr (0.058 mg/kg b.w.) was significantly greater than that estimated from dermal plus inhalation monitoring (0.013 mg/kg b.w.) $p < 0.01$, suggesting that the methodology used to assess exposure did not provide a comprehensive assessment.

**1990-1993:** Urine and air monitoring data were collected on three workers applying triclopyr to Louisiana roadways at an application rate of 0.84 acid equivalents per hectare over four spray seasons from 1990 to 1993.[20] The amount of triclopyr detected in urine per day ranged from non-detectable to 438 μg, and in breathing space air from 2 to 35 μg.

**1990:** A study was conducted in sixteen forestry worker volunteers at three different sites applying Garlon 4 using backpack sprayers and handguns. Four to six pounds (1.82 to 2.72 kg) of triclopyr were applied per day.

Dermal exposure was monitored by applying body surface patches and use of hand rinses. Inhalation exposure was monitored by personal air concentration in the breathing zone. All urine was collected over a five-day period—the day before, the day of, and three days after application—to obtain the amount of triclopyr excreted in order to estimate absorbed dose.

The mean exposure rate was 0.004 (0.00035–0.01428) mg/kg per lb a.e. handled. Neither of two workers with the highest exposure rates (0.01428 and 0.01176 mg/kg-lb) wore gloves. The mean exposure rate of 0.00221 (0.0015–0.00506) mg/kg per lb a.e. was much lower when including only the fourteen workers who wore gloves. The mean dermal absorption rate was 0.046 mg/hour (0.0163–0.0873). Personal air levels ranged from 5 to 15 $\mu g/m^3$.[21, 22]

### 4.2.5 Pesticide Illness Reports

The California PISP reported 17 cases of triclopyr-related pesticide incidents in ten years as shown in Table 4-1. All were local irritant effects and there were no cases of systemic poisoning. The most important immediate concern to workers is skin and eye irritation, which can be mitigated with protective clothing and good work practices; long-term effects of human exposure to triclopyr are not known. There are no incidents involving triclopyr in either TESS or SENSOR pesticide surveillance systems.

**Table 4-1: Triclopyr-related Illnesses Reported by California Physicians to the Pesticide Incident Surveillance Program (PISP) 1987 to 2004**

| | Respiratory | | Skin/Eye | | |
|---|---|---|---|---|---|
| Year | Definite/Probable | Possible | Definite/Probable | Possible | Total |
| 2004 | 2 | 1 | - | - | 3 |
| 2003 | - | 3 | | - | 3 |
| 1999 | - | - | 1 | - | 1 |
| 1997 | - | 2 | - | - | 2 |
| 1996 | 1 | - | - | - | 1 |
| 1992 | - | - | 1 | 1 | 2 |
| 1991 | - | - | 1 | - | 1 |
| 1989 | - | - | 1 | - | 1 |
| 1988 | - | - | 1 | - | 1 |
| 1987 | - | - | 2 | - | 2 |

*Data source:* CA DPR Pesticide Illness Surveillance Program, reference 23.

## *4.3 Triclopyr Toxicity to Animals and Plants and Levels of Concern*

This section of the report summarizes triclopyr toxicity to nine taxa groups, including mammals, birds, fish, amphibians, terrestrial and aquatic invertebrates, terrestrial and aquatic plants, and soil microorganisms. Although triclopyr has been registered in the US since 1979, there are still very few studies on triclopyr that are not part of the EPA registration process, thus most of the toxicity data is from studies conducted by the manufacturer.

The acute oral, dermal and inhalation toxicity in mammals of triclopyr acid and triclopyr BEE is low. Triclopyr BEE is rated as Category III (slightly toxic) for mammals. The toxicity of

triclopyr BEE to aquatic organisms is relatively high compared to glyphosate. Triclopyr toxicity to wildlife ranges from not acutely toxic to slightly acutely toxic for birds and honeybees, and slightly to highly acutely toxic in fish, amphibians and aquatic invertebrates. Aquatic toxicity depends strongly on the triclopyr formulation—triclopyr BEE is more toxic to aquatic organisms than triclopyr acid. Triclopyr's effects on soil microorganisms are not well defined.

The primary degradation product of triclopyr, TCP, is more toxic than triclopyr to mammals and aquatic organisms.

Levels of concern for triclopyr and TCP are summarized in this section, with Tables 4-7 and 4-8 starting on page 4-40 presenting the toxicity reference values (TRVs) selected for this risk assessment and the USFS TRVs for comparison.

In general, we used the same TRVs as the USFS, unless additional data were available indicating toxicity at concentrations below the USFS TRV, or when only $LC_{50}$ values were available instead of NOECs. The adjustment employed to convert an $LC_{50}$ to a NOEC is based on EPA's standard practice for endangered species effects determinations,[24] and involves dividing the $LC_{50}$ by a factor of ten for birds and mammals or a factor of 20 for aquatic species.

Toxicity reference values for triclopyr BEE and triclopyr acid are discussed. For long-term runoff where several months might pass before a rainstorm with sufficient volume to cause runoff occurs, TRVs for the triclopyr degradation product 3,5,6-trichloro-2-pyridinol (TCP) are used. This is appropriate, since and triclopyr BEE are transformed relatively rapidly in the environment to triclopyr acid, which degrades primarily to TCP.

### 4.3.1 Mammals

Most of the data on toxicity of triclopyr to mammals is from studies in laboratory animals for support of registration of the herbicide with the EPA. There are very few studies of triclopyr available in the open literature, and the discussion below is based on unpublished studies summarized in the EPA RED[10] and the USDA Forest Service review.[6] Results of studies of laboratory animals are summarized in Tables 4-2 to 4-6. The EPA considers triclopyr acid (3,5,6-trichloro-2-pyridinyloxyacetic acid) and its triethylamine salt (TEA) and butoxyethyl ester (BEE) as bioequivalent in toxicity to mammals.

Triclopyr is poorly absorbed through the skin and has low acute oral, dermal and inhalation toxicity. It can be a mild to severe eye and skin irritant depending on the formulation. The studies on sensitization (allergic dermatitis) are ambiguous. Triclopyr causes severe birth defects in rats at relatively low levels of exposure (NOEL = 5 mg/kg-day), and the US EPA reference dose for triclopyr of 0.05 mg/kg-day for women of childbearing age is based on this effect. Adverse liver and kidney effects and hematological changes have also been noted in animal studies. The triclopyr degradation product TCP is a developmental toxicant with a NOAEL of 25 mg/kg-day and causes changes in blood chemistry in chronic exposure studies.

The EPA classified triclopyr as Group D (Not Classifiable as to Human Carcinogenicity) in 1998 based on a consensus recommendation of the agency's Carcinogenicity Peer Review Committee (CPRC). The CPRC's review found the animal evidence to be marginal (not entirely negative,

but yet not convincing) and not supported by additional data from structural analogs or genotoxicity data. This decision was in contradiction to the 1986 EPA guidelines requiring a compound to be classified as a carcinogen if it caused cancer in two species of laboratory animals. The latest revised guidelines are more lenient, allowing the EPA to exercise considerable judgment based on the nature and quality of the data.

There are much more data on reproductive effects of triclopyr, several of which found adverse maternal and development outcomes, including fetal malformations (see Table 4-6). Maternal toxicity was high, and the most severe adverse outcomes were found at the highest dose tested (HDT). A study of the reproductive and developmental effects of TCP, the major metabolite of triclopyr, found adverse effects on fetal development at dose levels that also produced maternal toxicity.

#### *4.3.1.A Metabolism and Pharmacokinetics of Triclopyr*

Triclopyr is poorly absorbed and rapidly excreted unchanged in the urine following oral and dermal administration. In rats fed 3 or 60 mg/kg of $^{14}$C-triclopyr acid, approximately 89 to 95 percent of unchanged triclopyr was recovered in the urine; very little residue was found in the feces or carcass. The half-time for oral absorption was 3.61 hours and for urinary excretion of unabsorbed triclopyr was 1.1 hours.[25] In rabbits administered a dermal dose of 0.5 to 2.1 mL of 50 percent Garlon 4E (diluted with water) applied five days a week for three weeks, average recovery of triclopyr in the urine was 8 to 9 percent of the applied dose (see sub-chronic section for further results of these studies)[26] In another study in rabbits, 1.5 percent of a 2 g/kg dose of triclopyr acid was absorbed through the skin.[27]

A lactating Holstein cow fed 454.4 mg of triclopyr in grain over a four-day period excreted 86.4 percent unchanged in the urine. No residues were found in the milk or feces.[28]

The pharmacokinetics of triclopyr is very different in the dog, which is unique in its limited capacity to clear weak acids from the blood and excrete them in the urine.[25] The Dow Chemical Company (manufacturer of triclopyr) was critical of the EPA's characterization of decreased kidney excretion of the red dye phenolsulfophthalein (PSP) in dogs as a toxic effect and using it as a basis for setting an acceptable level of exposure for triclopyr. Studies conducted by the company showed that PSP is competing with triclopyr for excretion in dogs, an effect that was not present in the monkey or the rat even at much higher doses.[29, 30] The EPA reclassified decreased PSP excretion in dogs as a physiological response and not an adverse effect.[31] Other effects on the kidney were reflected by changes in clinical chemistry (blood urea nitrogen (BUN) and creatinine) are classified as adverse effects and are discussed further in the sub-chronic section.

**TCP metabolite:** The major metabolite of triclopyr in mammals is 3,5,6-trichloro-2-pyridinol (TCP), which is also the major metabolite of the organophosphate insecticide chlorpyrifos (Dursban, Lorsban). The organothiophosphate structure found in chlorpyrifos is not present in either TCP or triclopyr, and neither are cholinesterase inhibitors. EPA derived a provisional acute Population Adjusted Dose (PAD) of 0.025 mg TCP/kg-day based on NOAEL of 25 mg/kg-day from a developmental toxicity study in rabbits, in which increased incidence of hydrocephaly and dilated ventricles in rabbits was seen at the next higher dose of 100 mg/kg-

day. An uncertainty factor of 1,000 was used to obtain the PAD. The chronic PAD of 0.012 mg TCP/kg-day is based on data from a chronic study in dogs using an uncertainty factor of 1,000.[11] Changes in clinical chemistry were found at a LOAEL of 48 mg/kg-day, but no effects at a NOAEL of 12 mg/kg-day. EPA has assessed the combined likely exposures to TCP from both triclopyr and chlorpyrifos using very high exposure assumptions, and found no risks of concern. TCP was not considered fetotoxic or teratogenic in either rats or rabbits, except at dose levels that produced maternal toxicity.[32]

**Other ingredients:** Garlon 4 Ultra contains 39.55 percent by weight of a non-petroleum, methylated seed oil solvent with lower toxicity than kerosene used in Garlon 4 formulations. Methylated seed oils are products of the reaction of plant oils such as soy and canola with methanol or ethanol and are generally characterized as not acutely hazardous.[33] Little is known about their sub-chronic toxicity, but it is not likely to be high (see Chapter 5). Low molecular weight methylated seed oils are approved as food additives and are classified by EPA as List 4B minimal risk inerts. The product label does not specify the molecular weight of the methylated seed oils in Garlon 4 Ultra.

#### *4.3.1.B Acute Toxicity of Triclopyr*

The acute oral, dermal and inhalation toxicity in mammals of triclopyr acid and triclopyr BEE is low (see Table 4-2). Products containing triclopyr may cause irritation to the skin and eyes, with technical grade triclopyr acid (technical) being a slight irritant Triclopyr BEE causes more severe skin reactions, most likely due to more rapid absorption. Both triclopyr acid and the BEE have been found to be sensitizers, causing allergic contact dermatitis (delayed hypersensitivity) in some studies but not others. Inhalation is not a major route of exposure to triclopyr because of its low volatility.

**Table 4-2: Acute Toxicity of Triclopyr in Experimental Animals**

| Mode | Formulation | Oral, Dermal $LD_{50}$ (mg/kg) Inhalation $LC_{50}$ (mg/L) | EPA Toxicity Category |
|---|---|---|---|
| Rat oral[34] | Technical grade | 1,915 M >2000 <5050 F | III |
| Rat oral[10] | Technical grade | >2000 M/F | III |
| Rat oral[35] | TEA (44.4% a.i.) | 594 M, 828 F | III |
| Rat oral[6] | BEE | 803 M,F | III |
| Rat dermal[36] | Free acid | 729 M, 630 F | III |
| Rabbit dermal[37] | Free acid or BEE | >2,000 | III |
| Rabbit dermal[38] | TEA (46.5%) | > 5,000 | IV |
| Rabbit dermal[39] | Technical grade | > 5,050 | IV |
| Rat inhalation[40] | TEA (44.4% a.i.) | > 2.6 M/F | IV |
| Rat inhalation[41] | BEE (97.1% a.i.) | > 4.8 M/F | IV |

**Dermal Exposure:** Triclopyr is poorly absorbed through the skin, which is reflected in high dermal $LD_{50}$ values ranging from 2,000 to >5,050 mg/kg as shown in Table 4-3. Both contact and allergic dermatitis from exposure to triclopyr have been studied in rabbits and guinea pigs. Triclopyr BEE causes more severe skin irritation than triclopyr acid or TEA, which may be due to more rapid absorption. Triclopyr TEA is not a primary skin irritant, but allergic contact sensitization was found in some studies, but not others.

**Table 4-3: Dermal Toxicity of Triclopyr to Mammals**

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Observed effects |
|---|---|---|---|
| Rabbits 6 M/F[39] | 4 hrs | 500 mg tech. covered intact skin | Slight irritation |
| Rabbit 5M/5 F[39] | 21 days | 5,050 mg tech. intact skin | Erythema in 4 of 10 animals |
| Guinea pig 10 M/F[42] | 24 hours | 400 mg tech. to intact skin | Not a sensitizer, no changes. |
| Guinea pig 10 M[43] | | Garlon 3A TEA undiluted | A sensitizer. Slight erythema in 4/10 animals. |
| Guinea pig 10 M[44] | | Garlon 3A50% TEA | Not a sensitizer, no changes. |
| Guinea pig 10 M[45] | | Garlon 3A 30% TEA | Not a sensitizer, no changes. |
| Guinea pig 10 M[46] | | Garlon 3A 15% TEA | Slight erythema in 3/10, 4/10, 1/10, and 2/10 animals. |
| Guinea pig 40 M[47] | | Garlon 3A (TEA) 0.4 ml + 4 dose levels ethyl pyridine | Slight erythema in 4/10, 3/10, 3/10, 1/10. Sensitization unrelated to ethyl pyridine contaminant |
| Guinea pig 40 M[47] | | Garlon 4 (BEE) 0.4 ml + 4 dose levels ethyl pyridine | Sensitization unrelated to ethyl pyridine contaminant. |
| Guinea pig10 M[48] Rat 5M 5F[49] | 1 day | Pathfinder II, 13.9% a.i (BEE) 7.5%, 2.5% to shaved backs. | Not a sensitizer. No mortality or treatment related gross pathology. |

**Ocular exposure:** There are three studies of ocular toxicity of triclopyr, all in rabbits, in which 0.1 ml by volume was applied to the conjunctival sac of one eye for 24 hours, washed out with deionized water for one minute and followed up for seven days. Triclopyr TEA was found to be corrosive,[50] triclopyr acid a mild irritant,[51] and triclopyr BEE a minimal irritant.[52]

**Inhalation exposure:** The vapor pressure of triclopyr acid is very low ($< 1 \times 10^{-8}$ mm Hg at 25°C) and that of triclopyr BEE is moderately low ($3.6 \times 10^{-6}$ mm Hg at 25°C), which is reflected in the high inhalation $LC_{50}$ consistent with low acute inhalation toxicity (see Table 4-2). There are three studies of the inhalation toxicity of triclopyr, all in rats. Two of the studies were to determine the inhalation $LC_{50}$ of triclopyr TEA and BEE.[41] In a study of ten Sprague-Dawley rats exposed to undiluted triclopyr technical fine powder at 2.5 mg/L, all exhibited decreased activity and piloerection. Body weight changes and abnormal necropsy findings of spotted lungs were found in one animal. This is the study on which EPA based its conclusion that inhalation exposure was not of toxicological concern.[10] More study is needed to confirm this conclusion.

**Intravenous exposure:** In the only intravenous study available, triclopyr BEE was administered to male and female black Bengal goats at 2.97, 5.94, and 11.88 mg/kg body weight.[53] There were no signs of toxicity at the two lower doses; at the HDT, signs of toxicity included depression (as measured by sluggishness and unresponsiveness) and drowsiness after 10 minutes, miosis and fixation of the eyelid, increased secretion of nasal discharge and salivation, irregular skin itching, muscle tremors mainly on the posterior portion of the body, slight increase of body temperature, and increased frequency of defecation until four and one-half hours after administration.

#### *4.3.1.C Sub-Chronic Toxicity of Triclopyr*

There is testing of more species for the sub-chronic toxicity studies of triclopyr than for any chemical discussed in this report, with data reported in the rat, mouse, rabbit, horse, monkey, and cow. The studies are summarized in Table 4-4 below.

The most common adverse effects were in the kidney, found in all species tested. Increased kidney weight was found in the rat and mouse, proximal tubule degeneration in the rat, decreased excretion of the red dye PSP (phenolsulfophthalein) in the rat, dog and monkey, increased urinary protein in the mouse, increased blood urea nitrogen (BUN) in the mouse and horse, and increased creatinine in the dog and monkey. Abnormal changes on necropsy were found in the rat, mouse and rabbit. Hepatic effects were the next most frequently found. Increased liver weight was found in the rat, increased liver enzyme levels (transaminases AST/SGOT, ALT/SGPT) in the rat, mouse and dog, and liver cell (hepatocyte) histopathological changes in the rat, mouse, and horse. Hematological changes (hematocrit, hemoglobin, red blood cell count) were found in one study in rats and one in dogs. Non-specific effects such as decreased body weight and food consumption were also found.

In a study of beagle dogs that was the basis of the 2.5 mg/kg-day NOEL for triclopyr, BUN levels were unaffected, but another study found a statistically significant 57 percent increase in BUN.[66] The EPA reclassified the 2.5 mg/kg-day as an adverse effect, and set the NOEL for effects on the kidney at the next lower dose of 0.5 mg/kg-day. This lowered the provisional chronic RfD to 0.005 mg/kg. In a 1995 study in dogs, the NOEL based on renal histological changes was set at 5 mg/kg/day, and the LOEL at 20 mg/kg/day.[54]

The EPA determined that risk assessments for short and intermediate term exposure were not required since the NOEL was > 1,000 mg/kg/day in a 21-day dermal toxicity study in rabbits.[55]

A large mammal study of six adult Shetland pony geldings found no adverse effects at the lowest dose tested (60 mg/kg), but very significant adverse effects at 300 mg/kg, with two out of six ponies dying as a result of the exposure. This study suggests that larger mammals may be more sensitive to triclopyr than smaller ones. The author concluded that acute poisoning from proper use of the herbicide was unlikely.[67]

#### *4.3.1.D Chronic Toxicity and Carcinogenicity of Triclopyr*

The EPA reports no increased cancer incidence associated with triclopyr exposure based on two available carcinogenicity studies, even though statistically significant increases in adrenal gland tumors (pheochromocytoma) were found in male rats and significant dose related increases in mammary gland adenocarcinoma were found in female rats and mice (see Table 4-5). There is an unpublished review of the cancer bioassay data on triclopyr submitted to EPA in support of its registration.[56] Having access to the unpublished documents, the USFS provided an analysis of the data and disputes about the accuracy of the cancer rating in the triclopyr risk assessment, quoted verbatim below:[6]

> ***3.1.10. Carcinogenicity and Mutagenicity.*** *Information regarding the mutagenicity and carcinogenicity of triclopyr has been reviewed in detail by U.S. EPA (U.S. EPA/OPP 1998a,b,c) as well as in the open literature (Cox 2000). A review of the cancer bioassay data on triclopyr as also been submitted to U.S. EPA in support of the registration of this compound (Goodman and Hildebrandt 1996).*
>
> *Standard bioassays for carcinogenicity have been conducted in both rats (Eisenbrandt et al. 1987) and mice (Tsuda et al. 1987). Both of these studies are*

*detailed in Appendix 5. In male rats and mice, no statistically significant dose-related trends in tumor incidence were apparent. Based on pair-wise comparisons (i.e., control group vs an exposed group), statistically significant increases were observed for some tumor types – benign and/or malignant pheochromocytomas combined as well as skin fibromas – in rats but not mice. In female rats and mice, there was a statistically significant dose-related increase in mammary gland adenocarcinomas.*

*The U.S. EPA/OPP (1998a) has reviewed these studies and determined that the evidence for carcinogenicity is marginal. This position is articulated briefly in the U.S. EPA/OPP (1998a) and, because of the importance of this decision to the risk assessment, the position is worth quoting directly:*

*"As a result of the August 9, 1995 meeting of the Agency's Carcinogenicity Peer Review Committee (CPRC), triclopyr was classified as a Group D chemical (not classifiable as to human carcinogenicity). This decision was based on increases in mammary tumors in both the female rat and mouse, and adrenal pheochromocytomas in the male rat, which the majority of the CPRC believed to be only marginal. Overall the majority of the CPRC felt that the animal evidence was marginal (not entirely negative, but yet not convincing). Therefore, the consensus of the CPRC was to classify triclopyr as a Group D chemical, based on what was considered only marginal response and the absence of additional support from structural analogs or genotoxicity. – U.S. EPA/OPP (1998a, p. 18)."*

*A detailed summary of the mutagenicity studies on triclopyr, most of which are negative, is detailed in Appendix 7.*

*The discussion of the potential carcinogenicity of triclopyr by Goodman and Hildebrandt (1996) is much more detailed and focuses on a re-evaluation of slides from the original studies as well as an assessment of tumor rates in historical controls. Both types of analyses are common and appropriate in the assessment of carcinogenicity data. Based on these analyses, Goodman and Hildebrandt (1996) assert that the triclopyr should not be classified as a carcinogen. In terms of the current risk assessment, this position has no impact: The decision by EPA/OPP (1998a) to classify triclopyr as Group D is accompanied automatically by a decision not to derive a cancer potency factor for triclopyr and hence, in terms of a risk assessment, the potential carcinogenicity of triclopyr is not considered quantitatively.*

*Cox (2000) has suggested that since triclopyr has been shown to cause at statistically significant dose-related increase in mammary gland tumors in both mice and rats, the U.S. EPA guidelines for cancer risk assessment indicate that triclopyr should be classified as a carcinogen. Cox (2000) cites the 1984 guidelines issues by U.S. EPA – i.e., FR 49: 46299-46300. The Agency has since issued additional draft guidelines in both 1996 and 1999, which are available at http://cfpub.epa.gov/ncea/raf/cancer.cfm. The 1984 guidelines do clearly indicate*

*that a compound will be classified as a carcinogen is it has been shown to cause cancer in two species of laboratory animals. The more recent guidelines, however, are less proscriptive and allow the Agency to exercise substantial judgment based on the nature and quality of the data.*

*Notwithstanding the evolution of the U.S. EPA guidelines for cancer risk assessment, the basic point raised by Cox (2000) is well taken and is the substantial concern to the current risk assessment. Triclopyr has been shown to cause the same type of tumors in two species. In addition, while all cancers are a public health concern, the particular tumor type noted in rats and mice (breast cancer) is a common and important form of cancer in humans. Nonetheless, it is worth noting that none of the dose groups in either rats or mice evidenced a statistically significant pair-wise increase in breast tumors. In other words, the magnitude of the response was not substantial. The other important factor discussed by U.S. EPA/OPP (1998a) is the apparent lack of mutagenic activity of triclopyr. As detailed in U.S. EPA/OPP (1998a), only one study – a dominant lethal assay detailed in Appendix 7 – indicated any form of mutagenic activity and the other standard assays for genotoxicity were negative. This is an important point because even if the U.S. EPA had decided to classify triclopyr as a carcinogen, it is plausible that a threshold dose-response assessment would be conducted. In the current risk assessment, a threshold based approach is used for standard toxicity and this approach is based on the most sensitive endpoint – effects on the kidney (USFS 2011, Section 3.4).*

*The only other potentially relevant information encountered in the literature is the epidemiologic report by Gambini et al. (1997). This study analyzes a cohort of rice farmers in Northern Italy, examining mortality patterns. The study attempts to determine whether excess risks for cancer could be detected and associated with chemical exposure. The study finds a significantly lower than expected number of deaths, with a slightly decreased overall cancer mortality. The study indicates that in 1990, 210 kg of triclopyr was used in the region of Italy in which the cohort of rice farmers lived.*

*This does not entirely alleviate concern for the potential carcinogenic activity of triclopyr. Based on a review of Eisenbrandt et al. (1987) and Tsuda et al. (1987) as well as the discussions in EPA/OPP (1998a) and Goodman and Hildebrandt (1996), there is no basis for asserting that these studies were seriously flawed.*

The EPA classified triclopyr as a Group D carcinogen (not classifiable as to human carcinogenicity) in 1998 based on a consensus recommendation of the agency's Carcinogenicity Peer Review Committee (CPRC). The CPRC's review found the animal evidence to be marginal (not entirely negative, but yet not convincing) and not supported by additional data from structural analogs or genotoxicity data.[10] This decision was strongly criticized by The Northwest Coalition for Alternatives to Pesticides (NCAP)[57] citing the 1986 EPA guidelines requiring a compound to be classified as a carcinogen if it caused cancer in two species of laboratory

animals.[58] The latest revised guidelines are more lenient, allowing the EPA to exercise considerable judgment in developing the ranking based on the nature and quality of the data.[59]

For non-cancer chronic effects, the EPA established the RfD based on a NOEL of 5 mg/kg-day for parental/ systemic toxicity in a two-generation study in rats based on the observation of proximal tubular degeneration of the kidneys of P1 and P2 parental rats at the next highest dose of 25 mg/kg/day (see Table 4-5).

**Table 4-4: Sub-chronic Toxicity of Triclopyr to Mammals**

| Test animal | Study Duration (days) | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| Rat Fischer 344 M/F[60] | 91 | 0, 5, 20, 50, 250 technical (98% a.i.) in diet | 5 (NOEL)<br>20 (LOEL) | Degeneration of kidney proximal tubules at ≥ 20 mg in males and females. Kidney wt increase in males at 50 mg in females at 250 mg. At HDT in males and females decreased activity, diarrhea, hunched posture, polyuria, facial swelling, stained walking on tiptoe (not found in survivors at day 6, decreased weight gain. GI tract, lung, liver, heart, and kidney abnormalities at necropsy. |
| Rat Fisher 344 weanlings M/F[61] 9 per sex per dose | 91 | 0, 7, 28, 70, 350 BEE in diet | 28, M (LOAEL)<br>< 7 F (LOAEL) | In males at HDT, decreased body weight and hematologic changes. In males at 28 and 20 mg increased kidney and liver weight. In females at 7 mg hematologic changes and increase in liver and kidney weight. Histopathological changes in the liver (hepatocellular hypertrophy with eosinophilia, necrosis) in males at > 70 mg and in females at HDT. Histopathological changes in the kidney (degeneration/regeneration of the descending proximal tubules) in males at 70 mg and in F at HDT and increased ALP, ALT and AST. |
| Rat Wistar M/F 25 each[62] | 21 | 24,240,480 dosed 5 days/week Garlon 4 dermal | 24 (LOEL) | Skin irritation very slight in males at 24 mg, slight to moderate in M/ F at 240 mg and severe in M/ F at HDT. At all dose levels in males significant growth retardation, and decreased food intake and food efficiency. At HDT in males and females abnormal behavior and histopathological changes in the skin. |
| Mice M/F[63] | 95 | 0, 50, 250, 1250 ppm[a] technical in diet | 240 (NOAEL) | At HDT in males, a 25% increase in water consumption at week13, a 25% increase in BUN (versus controls) at 26 weeks, and a 17% increase in liver weight at week 26 only. At HDT in females a 10-16% increase in kidney weight, and an increase in urinary protein at week 52. Histopathology findings did not support a true toxic effect on the kidney in males or females. |
| Mice M/F[63] | 28 | 0, 30, 60, 120, 240, 480 technical in diet | 60 (NOEL) | In males at ≥ 120 mg liver changes of centri-lobular swelling and degeneration of hepatocytes; at 240 mg mild increases in liver enzymes, and at 480 mg single cell necrosis of the liver, significant increases in liver enzymes alkaline phosphatase, AST/SGOT, and ALT/SGPT, with liver enlargement and dark color. |

| Test animal | Study Duration (days) | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| Rabbit NSW<br>M/F one each[26] | 21 | 500 ( 2.1 mL)<br>BEE dermal | only 1 dose tested | Severe effects limited to skin: moderate erythema, slight edema, distinct scaliness, slight to distinct necrosis, histopathology changes at necropsy. |
| Rabbit NSW<br>F two per dose[26] | 21 | 125, 250<br>(0.5, 1.0 ml)<br>BEE dermal | 125 (LOAEL) | Skin effects moderate at low dose and moderate to severe effects at HDT. Histopathology showed slight to moderate lesions of the skin. |
| Rabbit NSW<br>5 M 5 F[34] | 7 | 1200 (M), 2000, 5050 technical to intact skin | 2,000<br>(NOEL) | Erythema in 4/10. No mortality, signs of clinical toxicity, or weight gain. Abnormal lung and kidney necropsy findings in 5/10.<br>No significant effects on body weight, food consumption, hematology, clinical chemistry; decreased PSP excretion at HDT. |
| Dog beagle<br>M/F 4 each dose, sex group[64] | 365 | 0, 0.5, 2.5, 5.0 technical (98.9% a.i.) | 0.5 (NOAEL) | In males and females no significant effects on mortality, clinical signs, body weight, or food consumption at any dose. Statistically significant increase in creatinine in 30% of males and 55% of females at 2.5 mg, and in 40% of males and 44% of females at 5.0 mg at 12 months. Significant increases in BUN at 2.5 even greater at 5 mg. Decrease in PSP excretion at 2.5 and 5.0 mg. No histopathologic changes in the kidney. |
| Dog beagle<br>M/F 4 each dose, sex group[65] | 184 F<br>183 M | 0, 0.1, 1, 0.5, 2.5 technical<br>in diet | > 2.5<br>(NOEL and LOEL) | No significant effects on body weight, food consumption, hematology, or clinical chemistry in male or females. At 2.5 mg decreased PSP excretion. |
| Dogs beagle M/F<br>M/F 4 each dose, sex group[66] | 228 | 0, 5, 10, 20 technical<br>In diet | < 5 (NOEL)<br><br>5 (LOEL) | In females, decreased body weight and food consumption at all levels and slight thinning of coat hair at 10 and 20 mg. Decrease in hemoglobin, hematocrit, and red blood cell count in males and females at 20 mg/kg/day. Increased ALT/SGPT in all females at all levels and in males at 20 mg; increased AST/SGOT in males and females at 20 mg. Decreased PSP excretion in males and females at all dose levels.[b] At necropsy decreased amounts of adipose tissue in females at 20 mg/kg/day; histopathology of minimal (reversible) degenerative changes in liver and kidneys in males and females at all dose levels. |
| Dogs beagle M/F<br>M/F 4 each dose, sex group[66] | | 0.5, 2<br>in gelatin capsule | 0.5 M<br>(NOAEL) | A supplemental study reported with the previous study. 2 mg resulted in a slight inhibition of PSP, which was reversible after a minimum of 10 days. |
| Monkey Rhesus<br>8 M[29] | 28<br>102 | 5<br>20<br>by gavage | <5 (NOAEL) | Body weight increase; no changes in BUN; initial slight increase over baseline in creatinine but no impact with repeated doses. Slight non-significant decrease in PSP excretion after 8 days at 5 mg; at day 24 exceeded baseline and in no case was it significantly reduced. |

| Test animal | Study Duration (days) | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| Shetland pony 6 each dose, 3 controls[67] | 4 | 0, 60, 300 by gavage | 60 (NOEL) | At HDT depression, recumbency, decreased GI activity, labored respiration, ataxia, stiffness, fine tremors. Pale liver with hepatosis, fatty changes. Kidney swelling, casts in renal tubules, increased BUN.[b] Two of six died and two of six euthanized on days 5 and 6. |
| Holstein Cow[28] | 4 | 5 ppm of 22.7 kg/day in feed (113.5 mg/day, for a total dose of 454 mg) | Not stated | Milk, urine, feces collected daily up to 6 days post dosing. 86.4% excreted unchanged in the urine with daily amounts in the first five days of 80.8, 94.9, 110.2, 102.8 and 4.0 mg. No residues found in milk or feces. No adverse effects reported. |

HDT = Highest dose tested; M = male; F = female; BUN = blood urea nitrogen: along with creatinine, measures the kidney's ability to filter out waste products of protein metabolism.; PSP = phenolsulfophthalein.; AST = aspartate aminotransferase, also known as SGOT (serum glutamic oxaloacetic transaminase) and ALT = alanine aminotransferase also known as SGPT (serum glutamic pyruvic transaminase) are enzymes normally inside liver cells that enter the blood stream when the liver is damaged.

[a] Equivalent to 5.55, 28.6, 143 mg/kg in males and 5.09, 26.5, 135 mg/kg in females.

[b] A 38-day supplemental study suggested the existence of a competitive mechanism of renal excretion for the triclopyr and PSP dye at dose levels of 1 or 2, but not 0.5, mg/kg/day.

**Table 4-5: Chronic Toxicity of Triclopyr to Mammals**

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Dose endpoint (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| Mice ICR M/F[63] | 95 weeks | 0, 50, 250, 1,250 ppm[a] technical (98.0% a.i.) in diet<br><br>Equivalent to 0, 5.55, 28.6, 143 mg/kg-day (M) and 0, 5.09, 26.5, 135 mg/kg-day (F) | 28.6, M (NOEL)<br><br>26.5, F (NOEL) | In males at HDT (143 mg), 25% increase in water consumption by week 13; 25% increase in BUN at 26 weeks; 17% increase in liver at week 26 only. In females at HDT (135 mg) 10-16% increase in liver weight, and in urinary protein at week 52. In females a significant increasing trend in mammary gland adenocarcinomas ($p<0.05$). No compound-related tumors in males. mice. Authors state no changes in kidney histopathology that support a true toxic effect on the kidney. NOEL based on decreased body weight gain. |
| Rat Fischer 344 M/F[65]<br>50 each sex per dose group[68] | 2 years[b] | 0, 3, 12, 36 Technical (98.0% a.i.) in diet<br>in diet | 12, M (NOEL)<br>36 F (NOEL) | In males at 3 and 12 mg a significant increase in adrenal medulla benign pheochromocytoma and benign/ malignant pheochromocytoma combined, and in skin papillomas and subcutaneous fibromas. In females significant trends in mammary gland adenocarcinoma and adenomas/ adenocarcinoma combined. In males at the HDT a significant 10-17% increase in kidney weight with a dose-related trend at 12 months. In males at 12 and 26 mg increased proximal tubule degeneration at 6 months. Increased pigmentation of proximal descending tubule (kidney) in females at all dose levels. Significant decrease in hemoglobin and hematocrit at 6 months and in red cell count and hematocrit at 12 months. |

HDT = highest dose tested; M = male; F = female; BUN = blood urea nitrogen.

[a] Equivalent to 5.55, 28.6, 143 mg/kg/day in males and 5.09, 26.5, 135mg/kg/day in females.

[b] Additional groups of 10 rats/sex/dose group exposed to same dose levels sacrificed at 6 and 12 months.

#### *4.3.1.E Reproductive and Developmental Toxicity of Triclopyr*

There are no reproductive studies of triclopyr in the open literature and only one of TCP, the major metabolite of triclopyr.[71] The discussion below relies on unpublished reports described in the USDA Forest Service review,[6] the EPA 2002 tolerance notice,[11] and the EPA RED.[10]

There are much more data on reproductive effects of triclopyr compared to other effects. Several studies found adverse maternal and development outcomes, including fetal malformations (see Table 4-6). Maternal toxicity was high, and the most severe adverse outcomes were found at the highest dose tested (HDT) of 100–300 mg/kg-day. A study of the reproductive and developmental effects of TCP, the major metabolite of triclopyr, found no adverse effects on fetal developmental or malformations in either rats or rabbits, even at dose levels that produced maternal toxicity.

Most of the studies of reproductive and developmental effects of triclopyr in the rat and rabbit find changes associated with maternal toxicity—decreased body weight and feed consumption in both species. More severe effects were found in rats, including rough hair, excessive shedding, salivation, difficulty breathing, tremors and abdominal discomfort at higher doses and death at the highest doses. Decreases in fetal weight and skeletal and ossification changes were found at dose levels associated with mild to moderate maternal morbidity. Major malformations occurred at levels that also cause severe maternal toxicity.

Other maternal effects reported were increased relative kidney weight in the rat and rabbit, and degeneration of the proximal tubules in the rat was found at moderate doses, and well as increased liver weight in both species. Lowered fertility, decreased uterine weight, and decreased numbers of litters and implantations were found in some studies.

Adverse effects on fetal and neonatal growth and development were also found and were dose-related. The most sensitive effect observed was the increased incidence of exencephaly (brain outside of the skull or not covered entirely by the skull) and ablepharia (congenital absence of eyelids) in second generation pups at maternal doses at a LOAEL of 25 mg/kg-day. The NOAEL is 5 mg/kg-day, which was used as the basisRfD for humans.

In other studies, rats at the highest doses tested exhibited decreases in pup weight, survival, litter size, and resorptions (abortion); minor skeletal and ossification changes were found. Major malformations were found in litters with severe maternal toxicity. In three of four studies in the rabbit no major malformations were found even at maternally toxic levels. At dose levels ≥100 mg/kg, an increase in resorptions (abortion), fetal deaths, and skeletal and ossification anomalies were found. A non-statistically significant increase in central nervous system anomalies at the highest doses tested in one study was also found in controls. The studies are summarized in Table 4-6 below.

**Table 4-6: Reproductive and Developmental Toxicity of Triclopyr to Mammals**

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| Rats S-D M/F 30 each sex and dose[69] | 2 gen $P_1$ 10 weeks $P_2$ 12 weeks | 0, 5, 25, 250 technical (99.4% a.i.) in diet | 5 (NOEL) parental, neonatal (pups)<br><br>25 (NOEL) fertility | No adverse effects adult or neonatal M/F at 5 mg. At 25 mg increase relative kidney weight in $P_1$ M and at HDT in $P_1$ and $P_2$ M/F. At 25 mg in both $P_1$/$P_2$ adults, degeneration of renal proximal tubules in some M/F at 25 mg and in the majority at HDT. No changes in reproductive organ M/F adults at any dose. At HDT in adult M/F decreased feed consumption and body weight, increased liver weight but no histopathology changes. At HDT significant decrease in pup weight, survival, and litter size in both $F_1$,$F_2$. Lower fertility and conception rates in $F_1$,$F_2$ generation attributed to females since no effect found on spermatogenesis. Increased incidence of F2 pups with exencephaly and ablepharia at 25 mg. |
| Rats S-D M 11-12 per dose F 23 per dose[70,71] | 3 gen | 3, 10, 30 Technical in diet | < 3 (NOEL) maternal and developmental | No effect on reproductive capacity, growth, or maturation. At 3 mg, third generation pups in one litter appeared weak and evidenced retarded growth, associated with non-functioning mammary glands in the dam. No similar effects at higher doses. |
| Rats S-D time mated[72] | Days 6-15 of gestation | 0, 30,100, 300 TEA (46.5%) by gavage | 30 (NOEL) maternal<br><br>100 (NOEL) developmental | At HDT clinical signs of maternal toxicity and one death. Developmental toxicity at HDT of decreased body weight, increased skeletal anomalies (reduced ossification, unossified sternebrae). |
| Rats CD, time-mated F[73] | Days 6-15 of gestation | 0, 30, 100, 300 TEA by gavage | 30 (NOEL) maternal | At 100 mg maternal morbidity with weight loss, increased water and decreased feed consumption. At HDT marked maternal morbidity, mortality, and increased kidney weights; fetal effects of decreased weight and delayed ossification. No teratogenic effects. |
| Rats S-D M/F 25 per sex per dose[74,75] | Days 6-15 of gestation | 0, 50, 100, 200 Technical by gavage | < 50 (LOAEL) maternal<br><br>100 (NOAEL) developmental | At all dose levels maternal toxicity—signs of rough hair, salivation, occasional dyspnea and tremors, and abdominal discomfort. At 100 and 200 mg food consumption and weight gain significantly depressed. No significant effects on implantations, viable fetuses, resorptions, or corpora lutea, fetal body weights or sex ratios. Litters of 200 mg dams had significant increase in retarded ossification of the skull bones, and 2 had major malformations (considered equivocal). Doses of 50 or 100 mg mildly toxic to dams but did not appear to cause adverse effects in developing fetuses. |

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| Rats CD, time-mated F[76] | Days 6–15 of gestation | 0, (5), 30, 100, 300 TEA or BEE by gavage | 30 (NOEL) maternal TEA<br><br>100 (NOEL) developmental TEA<br><br>5 (study authors) or 100 (independent interpretation) (NOEL) maternal BEE<br><br>100 (NOEL) developmental BEE | At 100 mg/kg-day TEA, slight maternal toxicity, evidenced by reduced feed consumption and increased water consumption. Decreased fetal body weight and reduced skeletal ossification at 300 mg/kg-day.<br><br>At 30-300 mg/kg-day BEE, slight but statistically significant decrease in maternal body weight gain early in study (days 6-8) with no clinical signs at any dose. Severe fetal malformations at 300 mg/kg-day. Experiment repeated with added dose of 5 mg/kg-day; increased incidence of 14th thoracolumbar rib at 300 mg/kg-day. |
| Rats S-D F adults[77] | Days 6-15 of gestation | 0, 50, 100, 200 tech. (98.5%) by gavage | 100 (NOEL) maternal and developmental<br><br>200 (LOEL) maternal and developmental | Dose-related, transient maternal toxicity (roughening of hair, excessive shedding) in all dose groups. At 100 and 200 mg body weight decreased 13% and 17% and food consumption. No significant effects on corpora lutea, implantations, or litter size. At 200 mg, increased resorption (complete resorption one entire litter only). A slight, non-significant decrease in fetal body weight HDT; two fetuses with cleft palate, brachycephaly (short broad head), and skeletal abnormalities. Minor soft tissue and skeletal variations observed in control and treated groups. |
| Rats CD time-mated F, 25 per dose Phase I; 30 per dose Phase II[78,68] | Days 6-15 of gestation | 0, 30, 100, 300 BEE (97.0%) by gavage **Phase 1**[a]<br><br>0, 5, 30, 100, 300 BEE (97.0%) by gavage **Phase II**[a] | 100 (NOAEL) maternal and developmental<br><br>300 (LOAEL) maternal and developmental | **Phase I**:[a] At HDT marked maternal toxicity with 4 four deaths, in a few dams, mean weight loss, decreased feed and increased water consumption, and increased mean liver and kidney weights, and increase in late *in utero* deaths. At all doses, slight reduction in weight gain and clinical signs of toxicity. At 100 mg, increased water consumption, decreased uterine weight and litter weight (not dose dependent). Dose-related increase in litters with malformed fetuses: 2 of 25 at 0 mg, 1 of 23 at 30 mg, 3 of 24 at 100 mg, 6 of 16 at 300 mg, with microophthalmia, anophthamia, retinal folding, cleft palate, other craniofacial abnormalities (misshapen lower jaw, hydrocephaly, rhinencephaly, agnathia). Malformed litters were from dams with the most severe signs of toxicity at HDT. decreased fetal weight, increased fetal and litter incidence of skeletal anomalies, increased fetal incidence of unossified sternebrae.<br>**Phase II**:[a] The only litter effect seen in both Phase I and Phase II was an increase in extra ribs at HDT; severe malformations were not seen. |
| Rabbit NZW F[79] | Days 6-18 of gestation | 0, 25, 50, 100 tech. by gavage | < 25 (NOAEL) maternal<br>100 (NOAEL) developmental | At all dose levels, maternal toxicity and mortality observed, but no toxicity to the developing embryo and fetus. No major malformation or soft tissue anomalies found at any dose level. |
| Rabbits NZW sexually mature F[77] | Days 6-18 of gestation | 0, 10, 25 tech (98.5% ) by gavage | Not stated | Transient, dose-related decreases in maternal body weight gain. No signs of treatment-related effects on fetal growth or development. |

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| Rabbit NSW F[80] | Days 6-18 of gestation | 0, 10, 30, 100 TEA by gavage | 10 (NOEL) maternal<br><br>100 (NOEL) developmental | At 100 mg severe maternal toxicity and mortality, including weight loss, decreased feed consumption, and increased liver and kidney weights. Increased abortions attributed to maternal toxicity. At 30 mg increase in abortions and early deliveries were associated with weight loss or anorexia in affected dams. No developmental or teratogenic effects at any dose level. |
| Rabbit NSW F[81] | Days 6-18 of gestation | 0, 10, 30, 100 BEE by gavage | 30 (NOEL) maternal and developmental | At 100 mg, severe maternal morbidity including weight loss and decreased feed consumption, and mortality; increased resorption, decreased litter size and litter weight, and increases in minor skeletal alterations (additional sterbral centers, reduced ossification of digital bones, and extra ribs). No teratogenic effects even at maternally toxic dose |
| Rabbit NZW F[81, 68] | Days 6-18 of gestation | 0, 10, 30, 100 BEE tech. (96.9%) by gavage | 30 (NOEL) maternal<br><br>100 (LEL) maternal | At HDT, maternal and developmental toxicity with decrease in number of live fetuses, decrease in number of live fetuses per dam, significant increase in post-implantation loss, increase in fetal deaths<br>an increased number of fetal and/or litter incidence of skeletal anomalies and variants (reduced ossification of sacrocaudal vertebral arches and cranial centers, and unossified sternebrae). |
| Rabbits NZW F[82] | Days 6-18 of gestation | 0, 10, 30, 100 TEA (46.5% a.i.) by gavage | 30 (NOEL) Maternal and developmental<br><br>100 (LOEL) maternal | Maternal toxicity at 100 mg/kg with increased mortality during test administration, decreased weight gain and food efficiency, and increased liver and kidney weights. Developmental toxicity at 100 mg/kg with decreased numbers of litters, corpus lutea, total implants, total live fetuses and increased embryonic deaths, deaths per dam, and increased pre-implantation loss. |
| Rabbit NZW 16 F inseminated[32] | Days 7-19 of gestation | 0, 25, 100, 250 TCP[b] by gavage | 25 (NOAEL) | AT HDT maternal mean weight loss of 70 grams (140 in controls); no clinical signs of toxicity. Fetuses evaluated on gestation day 28. No effect on fetal weight or viability. A non-statistically significant increase in central nervous system anomalies (also found in controls). |
| | **Acute RfD for general population** | | **100 mg/kg-day/ (10*10)[c]= 1.0 mg/kg-day** | **RfD based on developmental toxicity test in rats, where unspecified "clinical signs" were observed on GD 7 at the next highest dose of 300 mg/kg-day. Study done with triclopyr BEE.** |
| | **Acute RfD for women age 13–50 (childbearing age)** | | **5 mg/kg-day/ (10*10)[c] = 0.05 mg/kg-day** | **RfD based on increased incidence of F2 rat pups with exencephaly (brain located outside of skull) and ablepharia (absence of eyelids) at the LOAEL of 25 mg/kg-day. Study done with triclopyr acid.** |

| Test animal | Study Duration | Doses Tested (mg/kg-day) | Dose (endpoint) (mg/kg-day) | Observed effects |
|---|---|---|---|---|
| | | **Chronic RfD** | **5 mg/kg-day/ (10*10)[c] = 0.05 mg/kg-day** | **RfD based on increased incidence of proximal tubular degeneration in the kidney in male and female P1 and P2 rats at the next highest dose of 25 mg/kg-day. Study done with triclopyr acid.** |

S-D = Sprague Dawley; NZW = New Zealand White; GD = gestation day; M = male; F = female; RfD = Reference dose.
Shaded rows are the studies on which the RfD is based. **Bolded rows summarize the acute and chronic RfDs.**
[a] Separate studies. Phase II conducted to assess the reproducibility of effects seen in Phase I.
[b] 3,5,6-Trichloro-2-pyridinol, the primary metabolite of triclopyr.
[c] Intraspecies uncertainty factor of 10 and interspecies uncertainty factor of 10.

#### *4.3.1.F Neurotoxicity*

There are no studies designed to detect potential adverse effects on the central or peripheral nervous system in mammals exposed to triclopyr. The neurological effects observed in rats, mice, rabbits, and dogs—lethargy, impaired coordination, weakness, labored respiration, and tremors—discussed above, were only observed at very high toxic doses, and may be secondary to effects on other affected body systems.

One *in vitro* neurotoxicity study is available. Triclopyr neurotoxicity and the neuroprotective effect of "SS31" a mitochondria-targeted antioxidant peptide, were investigated in cultured mouse neuroblastoma (N2a) cells and primary neurons from C57BL/6 mice.[83] Significantly decreased total RNA content, cell viability, and mRNA expression of neuroprotective genes (peroxiredoxins) were reported in N2a cells treated with 3 mM triclopyr (formulation not specified). Decreased neuronal branching and degenerating neurons were observed. The antioxidant peptide SS31 prevented the effects of triclopyr in both cell culture and the intact neurons. However, little can be inferred from these results since only a single dose was used and the biological significance of the observed effects *in vitro* relative to a whole organism is not immediately obvious.

#### *4.3.1.G Immunotoxicity*

The powerful protective immune system is highly complex and interacts with all other body systems. The only way to determine potential immunotoxic effects of triclopyr is to directly study its effects on the immune system, including lymphoid tissue (lymphoid nodes, thymus), bone marrow, lymphocytes (B-cells and T-cells), antibodies, immunoglobulins, among and other components.

No reports of any abnormalities in lymphoid tissues were found in the studies reviewed for this summary, except thymic enlargement in mice in one study.[65] The only studies related to the immune system that have been performed with triclopyr are those that test skin sensitization (delayed hypersensitivity, allergy) in rabbits and guinea pigs—one found sensitization, but most did not (see Table 4-3).

The US Forest Service (2002) review notes:

> *"In these reviews of the toxicity of triclopyr, morphologic abnormalities in lymphoid tissues – indicative of potential damage to the immune system – have*

*not been reported. Since histopathologic evaluations of lymphoid tissues and evaluation of blood leukocyte counts are standard procedures in most rodent bioassays and since positive effects in these tissues would typically be reported prominently, it is reasonable to assert that these effects were not noted in the many standard bioassays of triclopyr."*

*"Equally important is the fact that the most sensitive effect for triclopyr is well characterized and involves damage of proximal tubular tissue of the kidneys. This is the endpoint selected by U.S. EPA as the basis for the RfD and is the same endpoint used in the SERA risk assessment for triclopyr. Protecting against this critical effect using the existing RfD is considered to be protective of all toxic effects and there is no specific information on the potential immunologic effects of triclopyr that raises significant questions concerning the protectiveness and adequacy of the current RfD" (page 27).*[84]

#### *4.3.1.H Endocrine Disruption*

The studies on reproduction and development in rats and rabbits suggest that triclopyr is not an endocrine disruptor, but it has not been studied for its potential to interact or interfere with estrogen, androgen, thyroid or other endocrine organ hormone systems. A European Union survey of the scientific literature on endocrine effects of pesticides does not list triclopyr as a chemical of concern,[85] nor do other sources of information on endocrine disrupting effects.[86] The surfactant Competitor that is being considered for use in this project does not contain the known endocrine disruptors nonylphenol or nonylphenol ethoxylate. However, no comprehensive evaluation of mixtures of triclopyr and this surfactant has been undertaken, and no final conclusions on the endocrine disrupting ability of these compounds or the mixture can be drawn at this time. Triclopyr is not one of the first sets of chemicals slated for testing of endocrine disrupting effects by the EPA. It is not clear when testing on this herbicide will be done.

#### *4.3.1.I Effects on Mammalian Wildlife*

US EPA's Ecotox database does not contain any field studies on the effects of triclopyr on wild mammals; however, the USFS risk assessment describes one study found that white-tailed deer avoided areas treated with herbicides followed by burning, but this avoidance may have been due to other factors besides herbicide treatment.[87] At normal field application rates of triclopyr, no adverse effects have been noted on reproductive activity in mammals, although few studies have been done.[88]

#### *4.3.1.J Size Differences in Mammalian Response to Triclopyr*

Triclopyr is more toxic to large mammals than to small mammals on the basis of dose per unit of body weight for sub-chronic and chronic exposures. For these longer-term exposures, a common endpoint of kidney damage was observed in the mammals that have been studied. The USFS risk assessment provides a good discussion of this allometric effect and the studies that demonstrate differences in sensitivity to triclopyr for small mammals such as rats and mice, compared to medium-sized mammals such as dogs, and large mammals such as ponies.[6] USFS developed an algorithm described by the allometric equation below to adjust TRVs for body weight.

$$Y = 451 * W^{-0.5}$$

where Y is the NOAEL or LOAEL and W is the body weight of the animal. The data are shown in Figure 4-1 below.

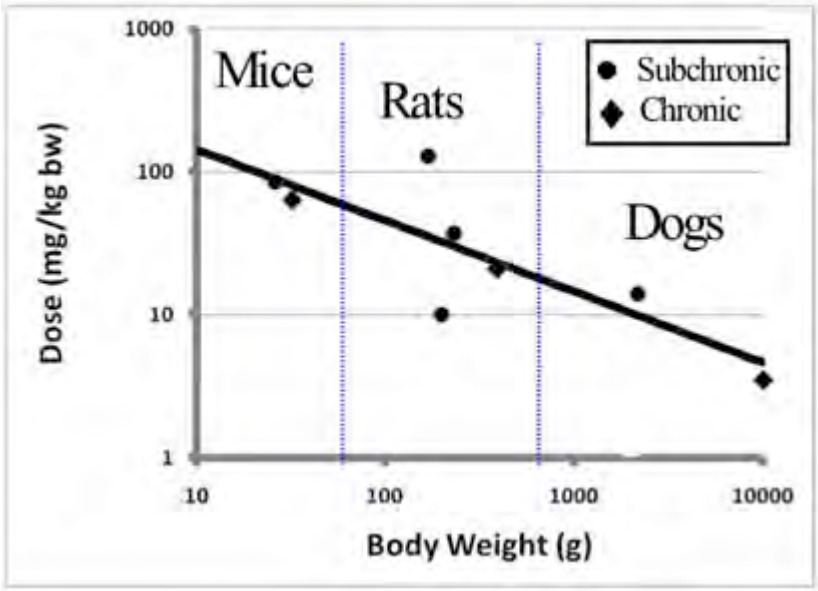



**Figure 4-1:** The dose at which adverse effects from triclopyr exposure begin to appear is a direct function of mammalian body weight.
*Data Source:* Reference 6.

The only data available for determination of allometric differences are from chronic and sub-chronic studies; however, the USFS also applied this same paradigm for assessing acute exposures. We did the same for the Mount Sutro risk assessment.

#### *4.3.1.K Levels of Concern for Mammals*

For the Mount Sutro risk assessment, we used the acute and chronic TRVs for triclopyr developed by the USFS. The NOAELs from the rat studies selected by US EPA for reference doses were used in conjunction with the allometric relationship described above in Section 4.3.1.J. Using representative body weights and the acute rat NOAEL of 100 mg/kg based on an increased incidence of increased mortality, increased kidney and liver weights and other clinical signs in adult rats and increased incidence of birth defects in pups at the next higher dose of 300 mg a.e./kg-day, the acute NOAEL for a small mammal (mouse) was estimated to be 440 mg/kg, a medium mammal (squirrel) was estimated to be the same as the rat at 100 mg a.e./kg and a large carnivorous mammal was estimated to be 20 mg a.e./kg.

The chronic TRV is based on a rat NOAEL of 5 mg/kg-day for proximal tubular degeneration of the kidneys in adult rats and birth defects in pups at the next higher dose of 25 mg/kg/day. Adjustments to this dose using the allometric relationship and body weights provided chronic TRVs of 22 mg a.e./kg for a small mammal (mouse), 5 mg a.e./kg for a medium mammal (squirrel), and 1 mg a.e./kg for a large carnivorous mammal. No adjustment of these values was performed to make them more protective because they were based on NOAELs measured in a mammalian species.

We also incorporated TRVs for the degradation product TCP into our analysis and used an acute TRV of 25 mg/kg-day, based on a NOAEL of 25 mg/kg-day from a developmental toxicity study in rabbits, in which increased incidence of hydrocephaly and dilated ventricles in rabbits was seen at the next higher dose of 100 mg/kg-day. The chronic mammalian TRV of 12 mg TCP/kg-day is based on data from a chronic study in dogs using an uncertainty factor of 1,000.[11]

### 4.3.2 Other Terrestrial Organisms

Triclopyr ranges from not acutely toxic to slightly acutely toxic to birds and honeybees. There is no information on non-honeybee insects. Trace amounts of triclopyr (<0.5% of application rate) can be toxic to non-target plants and possibly toxic to bryophytes (mosses). The maximum permissible application rate of Garlon 4 Ultra to brush and forests is 9 kg/ha, and 4.5 kg/ha for perennial weeds. There is some evidence that triclopyr is mildly toxic to mycorrhizal fungi at these application rates. The TRVs for terrestrial organisms are summarized in Table 4-7.

#### *4.3.2.A Birds*

On an acute basis, triclopyr has been classified as slightly toxic to birds. The EPA chemical registration studies provide most of the available data on avian toxicity, including reproductive toxicity. Triclopyr appears to be moderately toxic to avian reproduction.

The eight-day oral $LD_{50}$ values for triclopyr range from 510 to 1,700 mg/kg of organism body weight. The $LC_{50}$ values range from 2,930 to 6,700 mg a.e./kg of food.[13] Studies used Garlon 4 (formulation of triclopyr butoxyethyl ester and a kerosene solvent), triclopyr butoxyethyl ester and triclopyr triethylamine salt. Although there are only a few studies to compare, there does not appear to be a large difference in the toxicity of triclopyr TEA and triclopyr BEE in birds. US EPA determined $LC_{50}$ values of 5,360 and 3,880 mg a.e./kg food for mallards for the TEA and the BEE compounds, respectively, equivalent to $LD_{50}$ values of 536 and 388 mg/kg-day. The lowest $LC_{50}$ value reported by EPA for triclopyr acid (formed when both triclopyr TEA and BEE dissolve or degrade in the environment) is 1,480 mg/kg food, which would result in an $LC_{50}$ of 148 mg/kg body weight, assuming a bird eats approximately 10% of its body weight per day. There is also a lower $LC_{50}$ for triclopyr TEA of 4,660 mg/kg food (466 mg/kg body weight).

Studies that evaluate acute NOAELs are less common. The USFS risk assessment describes a study submitted by the registrant (not publicly available) in bobwhite quail dosed by gavage with triclopyr BEE.[6] The NOAEL was 126 mg a.e./kg-day.

The principal degradate of triclopyr, TCP, appears to be less toxic than triclopyr to birds, with an acute LD50 in bobwhite quail of >2,000 mg/kg.[6] Another study reported in the USFS risk assessment provides a NOAEC of 125 mg/kg for TCP, based on weight loss at the next higher dose of 250 mg/kg.

Avian reproductive studies were conducted for triclopyr as part of the EPA registration process. The NOAEC for weight loss and decreased reproductive success in quail and mallards was 100 mg/kg of food.[89] Based on body weight and food consumption data, the USFS estimated this concentration to be equivalent to a dose of 7.5 mg a.e./kg-day for quail and 10 mg a.e./kg-day for mallards. At this dose, statistically significantly fewer offspring survived to be 14 days old. A

2007 study by Dow AgroSciences reviewed in the USFS risk assessment reported a NOAEC of 400 ppm in mallards, which equates to a NOAEL of 56 mg a.e./kg-day.

**Levels of concern for birds:** For the Mount Sutro risk assessment, we used the same acute and chronic (reproductive) TRVs for birds as used by the USFS. The acute TRV is the NOAEL of 126 mg a.e./kg-day, based on body weight reduction in quail. The chronic avian TRV is the lowest NOAEL of 7.5 mg a.e./kg observed in a reproductive toxicity study. There was only a single acute study on the toxicity of TCP to birds, with a LOAEL of 116 mg/kg-day. We divided by the additional factor of 10 used by US EPA to protect endangered species, giving a TRV of 11.6 mg/kg-day (see Section 2.5.6). No chronic studies were available on TCP in birds; we used the acute TRV of 11.6 mg/kg-day, which is very close to the mammalian chronic TRV of 12 mg/kg-day.

#### *4.3.2.B Terrestrial Invertebrates*

EPA classified triclopyr as not acutely toxic to honeybees, the only terrestrial invertebrate for which there is information in the Ecotox database. Acute contact toxicity studies in honeybees give $LD_{50}$ values that range from 25 to over 100 µg/bee. The study used by US EPA provided an $LD_{50}$ >72 µg a.e./bee. At this dose, mortality was 26%, compared to 6% for the negative controls and the second highest dose tested of 43 µg a.e./bee.

**Levels of concern for bees:** For the Mount Sutro risk assessment, we used the contact $LD_{50}$ of 72 µg a.e./bee $LD_{50}$ for triclopyr acid as the basis for the TRV. A bee was assumed to weigh 0.000116 kg, corresponding to dose of 620 mg a.e./kg body weight. This value was divided by a factor of 20 to provide a surrogate NOAEC of 31 mg a.e./kg, according to US EPA's method for protecting endangered species.[24]

#### *4.3.2.C Terrestrial Plants*

As a selective herbicide for controlling broadleaf plants, triclopyr is toxic to many non-target plant species. Triclopyr and other pyridinecarboxylic acid herbicides (*e.g.* picloram and 2,4-D) mimic indole auxin plant growth hormones. Auxins help control plant growth; triclopyr disrupts the system by causing uncontrolled growth. At sufficiently high levels of exposure, the abnormal growth is so severe that vital functions cannot be maintained and the plant dies.[90a, b, c, d] Triclopyr is far more toxic to dicots than to monocots or conifers.

For all herbicides, US EPA requires manufacturers to perform seedling germination and emergence and vegetative vigor studies in non-target plants (including effects on corn and soybean). The EPA reregistration decision summarizes these studies for both triclopyr TEA and triclopyr BEE.[10] Seedling germination studies involve submersion of seeds in solution with triclopyr. Both of these tests simulate the effects of herbicide-contaminated runoff on emergent vegetation. Vegetative vigor studies involve direct foliar applications to young plants and simulate the effects of spray drift.

Triclopyr TEA has similar toxicity in both the seedling emergence and vegetative vigor assays, with the lowest NOEC being 0.0028 lb a.e./acre for seedling emergence in soybeans and 0.0028 lb a.e./acre for vegetative vigor in sunflowers. Triclopyr BEE has a greater effect on vegetative vigor, with a NOEC of 0.0028 lb/acre in sunflowers, compared to a NOEC of

0.02 lb/acre for seedling emergence in onions. The degradation product TCP is not toxic to plants.

**Levels of concern for terrestrial plants:** For the Mount Sutro risk assessment, we used the same TRVs selected by the USFS, based on a seedling emergence NOEC of 0.0028 lb a.e./acre for sensitive plants exposed to triclopyr acid and a vegetative vigor NOEC of 0.0028 lb/acre for sensitive plants exposed to triclopyr BEE.

#### *4.3.2.D Soil Microbes*

Data are sparse on the effects of triclopyr on soil microorganisms, but several studies are available showing that triclopyr is toxic to some species of soil fungi. Garlon 4, at concentrations of 0.74 ppm in growth medium (agar) over 26–48 days, can inhibit growth in the mycorrhizal fungi *Pisolithus tinctorius,* and *Hebeloma longicaudum.*[91] Mycorrhizal fungi are symbionts with plants that provide water and mineral nutrients in exchange for plant carbohydrates. *Cenococcum geophilum*, the slowest growing fungus, was least sensitive to the effects of triclopyr, exhibiting decreased growth at 742 ppm a.e.

A similar study found that triclopyr (formulation not reported) could inhibit growth in five mycorrhizal species: *Hebeloma crustuliniforme, Laccaria laccata, Thelophora americana, Thelophora terrestris,* and *Suillus tomentosus*.[92] The most sensitive species, *Thelophora americana*, exhibited a 6% decrease in growth rates relative to controls at triclopyr concentrations of 0.072 ppm (this result was statistically significant). In other species, statistically significant decreases in growth were reported between 0.72 ppm and 7.2 ppm.[92] Soil concentrations of triclopyr are typically 4–18 ppm following application of 0.28-10 kg/ha.[91] At realistic application rates, triclopyr could affect some fungal communities, but the data are sparse, and there is significant uncertainty about the potential effects of triclopyr on soil microorganisms.

The USFS used GLEAMS modeling to estimate long-term concentrations of triclopyr in soil over time, estimating that an application rate of 1 lb/acre would result in long-term soil concentrations that are well below 0.1 ppm—in the range of 0.02 to 0.05 ppm. Peak concentrations would be in the range of about 0.2 ppm. The USFS concludes that transient inhibition in the growth of some bacteria or fungi might be expected, which could result in a shift in the population structure of microbial soil communities, but substantial long-term impacts on soil would not be anticipated.

**Levels of concern for soil microbes:** There are no soil microbe exposure models available. Further, endpoints varied considerably in the available toxicity data. Some species showed inhibited growth at 740 ppm a.e., and similar effects were observed on other species with doses as low as 0.074 ppm a.e. The USFS did not develop a TRV for soil microbes because there is insufficient information to model triclopyr hazards to soil microbes.

### 4.3.3 Aquatic Organisms

The aquatic toxicity of triclopyr varies by product formulation and the active ingredient. The butoxyethyl ester (BEE) of triclopyr is considered moderately to highly acutely toxic to fish, moderately acutely toxic to amphibians and moderately to highly acutely toxic to aquatic invertebrates and aquatic plants. The degradation product triclopyr acid is much less toxic. There is less information available on the toxicity of triclopyr to amphibians, in part because the EPA does not require amphibian studies for registration. Toxicity data for both triclopyr BEE (active ingredient in Garlon 4 Ultra), triclopyr acid, and the degradation product TCP are presented here. The TRVs for aquatic organisms are summarized in Table 4-8.

The risk analysis is more complex for aquatic organisms because of the variation in toxicity between the different forms of triclopyr and the time frame of triclopyr BEE degradation relative to potential exposures. Triclopyr BEE degrades fairly rapidly in the environment (half-life of a few days to a few weeks) to triclopyr acid, which then degrades over a longer time frame (half-life of a few weeks to a few months) to 3,5,6-trichloro-2-pyridinol (TCP). Aerobic degradation of triclopyr in soil produces the metabolites TCP, $CO_2$, and 3,5,6-trichloro-2-methoxypyridine (TMP).[93] In a lab soil-column study, the relative amounts of these products at 54 days were 4% triclopyr, 81% TCP, and 15% TMP for triclopyr acid-treated soil. For triclopyr BEE-treated soils, concentrations were 6% triclopyr, 88% TCP and 6%TMP.[94]

In the analysis of risks to aquatic species, we provide hazard quotients (HQs) for triclopyr BEE, triclopyr acid and TCP. The TRVs for triclopyr BEE are used for determining HQs for acute scenarios such as spills, since this is the active ingredient under consideration for use in Mount Sutro watersheds, and no degradation will have yet occurred at the time of a spill.

The HQs for exposures to all three compounds are provided for evaluating exposures from peak and long-term runoff. A peak runoff event that occurs within a few days of application of Garlon IV Ultra will result in exposure primarily to triclopyr BEE, since little degradation will have taken place. As time progresses, degradation of the applied BEE compound will occur to form triclopyr acid and then TCP. For long-term runoff where aquatic organisms may be exposed over several months, the primary compounds of concern will be triclopyr acid and TCP, since triclopyr BEE will have degraded to the acid within a few days. For either peak runoff or long-term runoff, organisms will likely be exposed to a mixture of these compounds. It is impossible to determine the precise mixture of compounds that might be present at a given time, but taking action to mitigate the worst-case scenario will ensure protection of species.

#### *4.3.3.A Fish*

Triclopyr toxicity to fish varies by product formulation. Garlon 3, with active ingredient triclopyr TEA, is considered not acutely toxic to fish. In contrast, Garlon 4 Ultra, with active ingredient triclopyr BEE, is moderately to highly acutely toxic. The toxicity of triclopyr acid is between that of the salt and the ester, due to its acidity and ability to lower the pH of a water body at high enough concentrations. The degradation product TCP is moderately acutely toxic.

There are enough fish toxicity studies available that the USFS was able to develop a frequency distribution for the data that allows comparison of the toxicity of triclopyr BEE, triclopyr TEA, triclopyr acid and Garlon IV (see Figure 4-2). The plot shows that triclopyr TEA is the least toxic

form of triclopyr, with $LC_{50}$ values above 10 mg a.e./L. Triclopyr BEE is the most toxic, with $LC_{50}$ values less than 1 mg a.e./L. The degradation product TCP is in between the toxicity of the TEA salt and the BEE compound. The toxicity of the formulated product (Garlon 4) is approximately the same as that of the active ingredient, which indicates that the other ingredients in the product mixture do not contribute substantially to the toxicity of the product. A complete description of the methods used to generate the frequency distribution plots is given in the USFS 2011 risk assessment for triclopyr.[6]

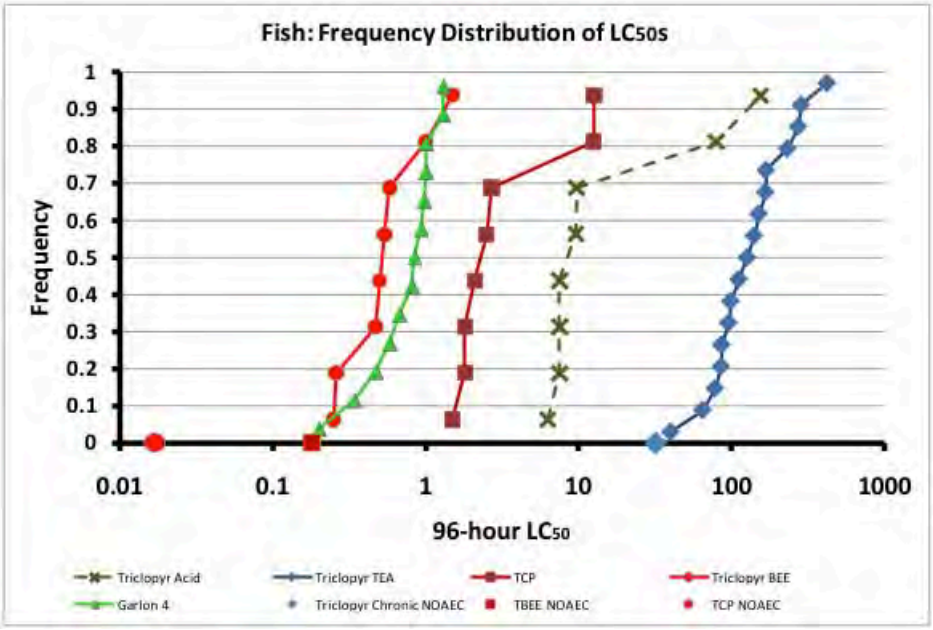



**Figure 4-2:** Frequency distribution of $LC_{50}$ values for various forms of triclopyr and degradation products for fish. Units on $LC_{50}$ data are mg/L. *Data source:* Reference 6.

**Levels of concern for fish:** For the Mount Sutro risk assessment, we started with the same TRVs selected by the USFS for sensitive fish and adjusted these doses by US EPA's factors for protecting endangered species when NOAECs were not available (see Section 2.5.6). For triclopyr BEE, the acute TRV is a NOEC of 0.091 mg a.e./L obtained from a study with bluegill sunfish. The chronic TRV is a NOEC of 0.019 mg a.e./L from a study with fathead minnows. For triclopyr acid, only studies with $LC_{50}$ values are available. The lowest acute value, 40.1 mg a.e./L for a study in silversides, was divided by a factor of 20 to give a surrogate acute NOAEC of 2.0 mg a.e./L, according to US EPA's methodology used to protect endangered species.[24] The same value was used as the chronic TRV since only a higher chronic NOAEC was available from a study with a tolerant fish. For TCP, the chronic NOAEC from a study with rainbow trout of 0.18 mg/L was used by both US EPA and USFS for both acute and chronic TRVs. We did the same.

#### *4.3.3.B Amphibians*

Although less information is available on the toxicity of triclopyr to amphibians, the data do indicate that Garlon 3A (triclopyr TEA) and triclopyr acid are much less toxic to amphibians than Garlon 4 (triclopyr BEE), similar to the relative sensitivity of fish. Garlon 3A is slightly

toxic to not acutely toxic in amphibians. Garlon 4 is moderately acutely toxic. There are no data available on the toxicity of TCP to amphibians.

The USFS risk assessment[6] provides a discussion of $LC_{50}$ values for amphibians exposed to triclopyr BEE in both embryonic and larval stages of growth. Embryonic $LC_{50}$ values range from 13.7 to 24.6 mg a.e./L. A NOAEC from a different study was found to be 2.5 mg a.e./L. The $LC_{50}$ values for larval amphibians were lower than those exposed as embryos and range from 0.79 to 11.5 mg a.e./L. No NOAECs were available, but an $EC_{10}$ for an avoidance response to triclopyr BEE-contaminated water was noted at 0.1 mg/L.

A study in which amphibians were exposed to triclopyr acid provided a NOAEC for growth of 125 mg a.e./L, which was used by the USFS as the acute and chronic TRV for triclopyr TEA and triclopyr acid.

For Garlon 3A, the 96-hour $LC_5$ and $LC_{50}$ values for the Frog Embryo Teratogenesis Assay[95] on *Xenopus laevis* (African clawed frog) are 119 and 162.5 mg a.e./L, respectively. The corresponding values for Garlon 4 (triclopyr BEE) were 6.7 and 9.3 mg a.e./L respectively.[96] No statistically significant increase in teratogenic effects was observed at sub-lethal concentrations.

In a study of *Rana pipiens* (leopard frog), *Rana clamitans* (green frog), and *Rana catesbeiana* (bullfrog), triclopyr acid reduced the response of amphibians to prodding.[97] Exposures to 0.6, 1.2, 2.4 and 4.8 mg a.e./L triclopyr acid caused no effect on hatching success or the incidence of malformations. However, all newly hatched tadpoles exhibited avoidance behavior of triclopyr-contaminated water. In leopard frog tadpoles, concentrations of 1.2, 2.4 and 4.8 mg a.e./L resulted in temporary dulled responsiveness or paralysis for 1, 3, and 5 days respectively. Newly hatched green frog and bullfrog tadpoles died when exposed to 2.4 or 4.6 mg a.e./L. For these two species, temporary decreased responsiveness lasted three days when tadpoles were exposed to 1.2 mg a.e./L.

**Levels of concern for amphibians:** For the Mount Sutro risk assessment, we used the same TRVs selected by the USFS for amphibians. A value of 0.1 mg a.e./L based on an $EC_{10}$ was used for both the acute and chronic TRV for triclopyr BEE. A value of 125 mg a.e./L, based on a NOAEC, was used for both the acute and chronic TRV for triclopyr acid. No data were available on the toxicity of TCP to amphibians, so we used the fish acute and chronic TRV of 0.18 mg a.e./L, similar to US EPA's standard methodology for estimating risks to amphibians. The paucity of data for amphibians increases the uncertainty of the risk estimates obtained using these TRVs.

#### *4.3.3.C Aquatic Invertebrates*

The information available for aquatic invertebrate $LC_{50}$ values suggests that the sensitivity of most invertebrates to triclopyr is similar to that of fish, with triclopyr BEE being much more toxic than triclopyr acid or TEA salt. The most sensitive species were terrestrial insects with aquatic life stages such as dragonflies and mayflies.

There are enough aquatic invertebrate toxicity studies available that the USFS was able to develop a frequency distribution for the data that allows comparison of the toxicity of triclopyr

BEE and triclopyr acid for several different taxa of aquatic invertebrates, including arthropods and shellfish (see Figure 4-3). While the data are not all directly comparable because they are based on different endpoints, the plot does indicate that triclopyr acid has low toxicity to aquatic arthropods, with $LC_{50}$ values above 100 mg a.e./L. Triclopyr BEE is the most toxic, with $LC_{50}$ values for arthropods less than 10 mg a.e./L. A complete description of the methods used to generate the frequency distribution plots is given in the USFS 2011 risk assessment for triclopyr.[6]

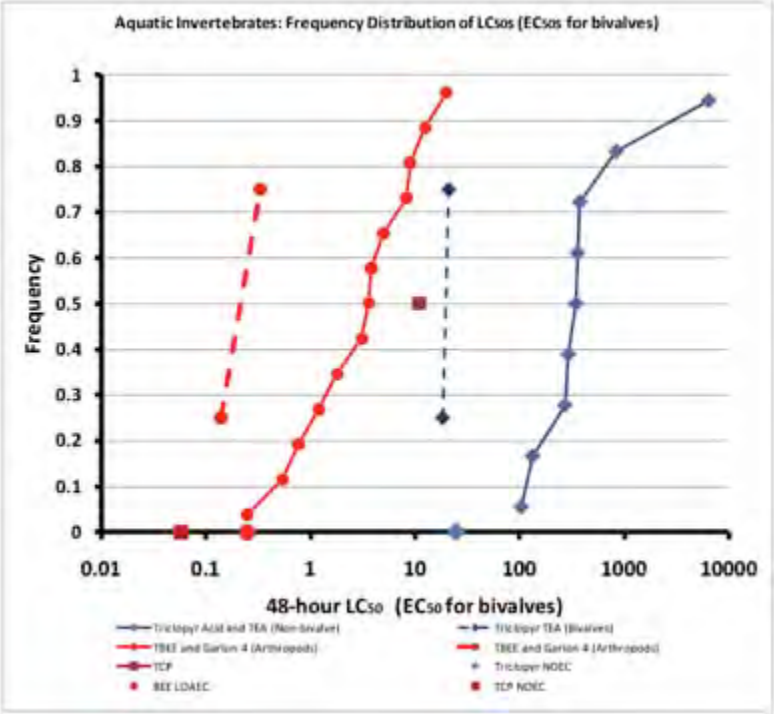



**Figure 4-3:** Frequency distribution of $LC_{50}$ and $EC_{50}$ values for various forms of triclopyr and degradation products for aquatic invertebrates. Units on the data are mg/L.
*Data source:* Reference 6.

In one study, *Daphnia magna* (water flea) adults were exposed to triclopyr TEA at concentrations of 57.9, 105, 204, 404, and 830 mg a.e./L for 21 days.[98] At the NOEC of 57.9 mg a.e./L, no significant effects were noted on mean number of broods, total young produced, mean number of young per brood or mean size of young. At the next higher concentration, 105 mg a.e./L, there was a statistically significant decrease in total young produced and mean number of young per brood.

Triclopyr TEA is much less toxic than triclopyr BEE to estuarine and marine invertebrates, with $LC_{50}$ values ranging from 58 to 6,400 mg a.e./L. The lowest $LC_{50}$ for triclopyr TEA for an estuarine invertebrate was 58 mg/L for an eastern oyster.[99] The $LC_{50}$ for the same species exposed to triclopyr BEE was 0.32 mg/L,[100] with a range of $LC_{50}$ values from 0.25 to 20 mg a.e./L. The highest $LC_{50}$ values for triclopyr TEA and BEE respectively are >1,000 mg/L for fiddler crabs[101] and 2.47 mg/L for estuarine shrimp.[102] It is unclear whether these studies are reporting acid equivalents or active ingredient.

NOAECs are not available for triclopyr TEA or triclopyr acid, but can be estimated by dividing $LC_{50}$ values by a factor of 20, according to EPA's methods for protecting endangered species (see Section 2.5.6), giving values of 2.9 to 320 mg a.e./L. A measured chronic NOAEC for daphnids exposed to triclopyr acid is 25 mg a.e./L, a value the USFS selected as the TRV for both acute and chronic exposures for aquatic invertebrates.

Several triclopyr BEE studies are discussed in the USFS risk assessment[6] that provide both $LC_{50}$ values and NOAECs. The data are used to predict NOAECs from studies yielding only $LC_{50}$ values. The ratio of the NOAEC to the $LC_{50}$ ranges from 0.11 to 0.63, with a mean of 0.38 and 90% confidence interval of 0.18 to 0.58. The USFS used the lower bound of 0.18 to estimate NOAECs from $LC_{50}$ values, which resulted in the lowest NOAEC being 0.045 mg a.e./L. This value was used as the acute TRV for triclopyr BEE. The USFS's chronic NOAEC of 0.25 mg a.e./L was based on a study with *Simocephalus vetulus*.

Terrestrial invertebrates with aquatic larvae, including Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), and Odonata (dragonflies), were evaluated for sensitivity to Garlon 4 (triclopyr BEE) by exposure in a flow-through system for one hour, with mortality assessed at 48-hours.[103] This exposure scenario mimics transient stream contamination from overspray. For most species, $LC_{50}$ values were greater than 290 mg/L; however, the trichopteran *Dolophilodes distinctus* showed high sensitivity in these tests, with $LC_{50}$ values averaging 0.6 (90% CI = 0.07–1.27) mg/L, and for one form of stonefly (*Pycnopsyche guttifer)*, an $LC_{50}$ of 61.7 (90% CI = 21.8–126) mg/L was observed. The authors indicate that there was high mortality in the controls and presented the results with some caveats. A second study that did not appear to have these experimental difficulties indicated that exposure of *D. distinctus* to a concentration of 3.2 mg/L for one hour resulted in 35% mortality after 24 hours. An $LC_{50}$ of 4.45 mg/L was calculated for this study.

A 2007 study of the toxicity of TCP and chlorpyrifos (a pesticide that also degrades to form TCP) to *Daphnia carinata* found an acute $LD_{50}$ for TCP of 0.0002 mg/L.[104] The toxicity of TCP to *D. carinata* was lower in natural water, and no effects were observed on *D. carinata* at concentrations of 0.002 mg/L. This value is not a NOEC, since other concentrations were not tested. The USFS summarizes another study on TCP submitted to US EPA as part of a registration package. This study used *Daphnia magna* and provided an acute $LC_{50}$ of 10.9 mg TCP/L and a chronic NOAEC of 0.058 mg TCP/L. Dividing by the factor of 20 for protection of endangered species, the acute NOAEC was estimated at 0.55 mg TCP/L.

**Levels of concern for aquatic invertebrates:** For the Mount Sutro risk assessment, we used the same TRVs selected by the USFS. A value of 0.045 mg a.e./L based on a NOAEC for sensitive invertebrates was used for both the acute and chronic TRV for triclopyr BEE. For triclopyr acid, a value of 25 mg a.e./L, based on a NOAEC, was used for both the acute and chronic TRV. For TCP, the acute TRV was based on an $LC_{50}$ of 10.9 mg TCP/L for *Daphnia magna*, divided by a factor of 20 to give 0.55 mg TCP/L, according to EPA's methodology for protecting endangered species. The chronic TRV of 0.058 mg TCP/L was based on a NOAEC for *Daphnia magna*.

### *4.3.3.D Aquatic Plants*

Triclopyr formulations range from slightly to highly toxic to aquatic plants. Based on $EC_{50}$ values, triclopyr TEA is about equally toxic to algae and aquatic macrophytes, with $EC_{50}$ values for algae having a geometric mean of 10.21 mg a.e./L and those for macrophytic monocots having a geometric mean of 9.47 mg a.e./L.[6] Dicots are more sensitive by approximately a factor of 100. Triclopyr BEE is more toxic than the TEA salt by about a factor of 10, with a geometric mean of $EC_{50}$ values of 1.03 mg a.e./L for algae and 2.3–2.6 mg a.e./L for macrophytes. The frequency distribution diagram for algae exposed to triclopyr is shown in Figure 4-4 below, with a clear distinction between the more toxic triclopyr BEE and the less toxic triclopyr acid and TEA salt. There are only two studies of TCP toxicity to algae, both with an $EC_{50}$ of 1.8 mg/L which show that TCP is between the BEE and TEA compounds in toxicity.

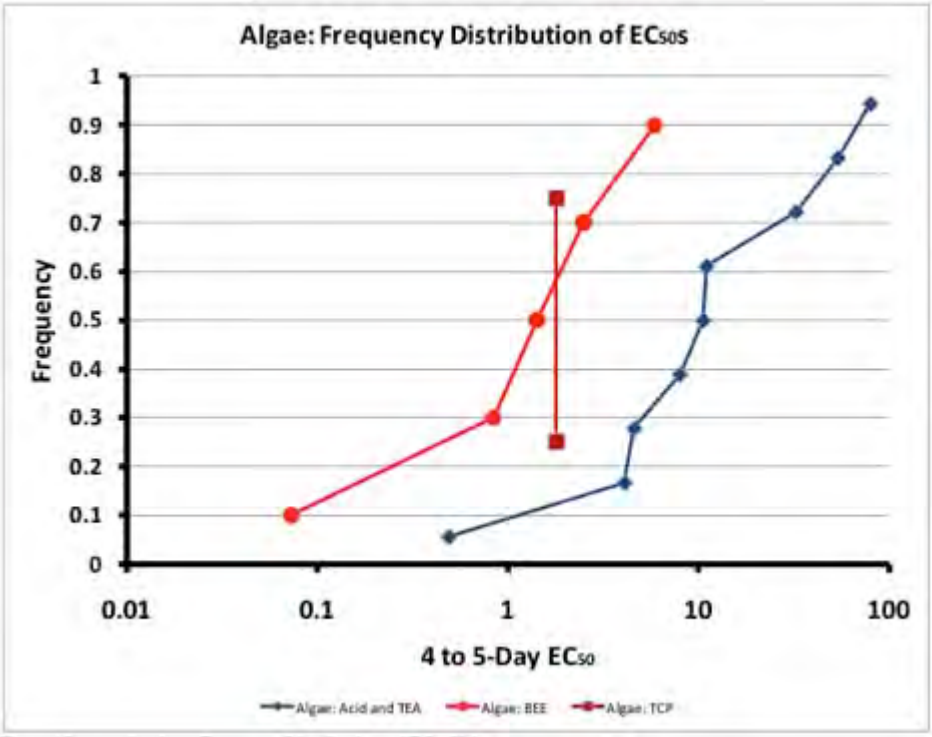



**Figure 4-4:** Frequency distribution of $EC_{50}$ values for various forms of triclopyr and degradation products for algae. Units on $EC_{50}$ data are mg/L. *Data source:* Reference 6.

The USFS discusses the use of several different statistical methods for derivation of NOAECs from $EC_{50}$ values in its risk assessment and draws the TRVs from this analysis.[6] We do not repeat that analysis here, but refer the interested reader to the USFS risk assessment document.

**Levels of concern for aquatic plants:** For the Mount Sutro risk assessment, we used the same TRVs selected by the USFS for algae, and did not evaluate effects on macrophytes because Woodland Creek is an ephemeral stream and does not support macrophytes. A value of 0.0014 mg a.e./L based on an estimated NOAEC for sensitive algae was used for both the acute and chronic TRV for triclopyr BEE. For tolerant algae, a value of 1 mg a.e./L was used as the TRV. For triclopyr acid, a value of 0.23 mg a.e./L, based on an estimated NOAEC was used for both the acute and chronic TRV for sensitive algae. For tolerant algae, a value of 4 mg a.e./L was

used as the TRV. For TCP, the TRVs for sensitive algae of 0.36 mg a.e./L and 0.65 mg a.e./L for tolerant algae were based on the $EC_{50}$ of 1.8 mg/L transformed to a NOAEC.

### 4.3.4 Data Gaps

Most of the literature cited in USFS 2011 and in the EPA's Terretox database comes from the re-registration and tolerance decisions for triclopyr. Before a chemical can be reregistered, the EPA requires: acute toxicity tests for mammals (as part of the human risk assessment), birds, fish, honeybees, and aquatic invertebrates; reproductive toxicity for birds; chronic toxicity tests for mammals; and very minimal chronic toxicity tests for fish, birds and aquatic invertebrates.

Acute toxicity information was available for representative surrogate species for all nine wildlife taxa, with substantial variability in sensitivity to triclopyr observed. More information describing this variability would better define the range of toxicity. LOELs were available for the sub-lethal effects of triclopyr for at least one surrogate species. Some sub-lethal toxicity information was available for selected taxa. More chronic toxicity information for all taxa would help to clarify possible sub-lethal effects. There were no data on the neurotoxicity or endocrine disrupting ability of triclopyr or its formulated products, and there were no studies for insects other than honeybees.

Field measurements of the effects of triclopyr in natural settings are rare. More field studies would help clarify the differences between laboratory and field toxicity of triclopyr.

Other good targets for future research include: sub-lethal toxicity studies (specifically endocrine disruption at sub-lethal concentrations), comprehensive field measurements of triclopyr residue concentrations on vegetation and in surface waters near application sites, and whole-ecosystem effects due to triclopyr exposure.

**Table 4-7: Comparison of Triclopyr and TCP TRVs Used in USFS and Mount Sutro Risk Assessments for Terrestrial Organisms**

| | | USFS | | | | Mount Sutro | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Exposure Type** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in USFS Risk Assessment** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in Mount Sutro Risk Assessment** |
| **Humans – Triclopyr BEE, TEA or Acid** | | | | | | | | | |
| | Acute RfD, general population | NOAEL (rat) | 100 mg/kg-day | ÷100[a] | 1 mg/kg-day | NOAEL (rat) | 100 mg/kg-day | ÷100[a] | 1 mg/kg-day |
| | Acute RfD, female | NOAEL (rat) | 5 mg/kg-day | ÷100[a] | 0.05 mg/kg-day | NOAEL (rat) | 5 mg/kg-day | ÷100[a] | 0.05 mg/kg-day |
| | Chronic RfD, all | NOAEL (rat) | 5 mg/kg-day | ÷100[a] | 0.05 mg/kg-day | NOAEL (dog) | 5 mg/kg-day | ÷1000[b] | 0.05 mg/kg-day |
| **Humans – TCP** | | | | | | | | | |
| | Acute RfD, all | NOAEL (rat) | 25 mg/kg-day | ÷1000[b] | 0.025 mg/kg-day | NOAEL (rat) | 25 mg/kg-day | ÷1000[b] | 0.025 mg/kg-day |
| | Chronic RfD, all | NOAEL (rat) | 12 mg/kg-day | ÷1000[b] | 0.012 mg/kg-day | NOAEL (rat) | 12 mg/kg-day | ÷1000[b] | 0.012 mg/kg-day |
| **Mammals – Triclopyr BEE, TEA or Acid** | | | | | | | | | |
| | Acute, medium mammal (squirrel) | NOAEL (rat) | 100 mg/kg-day | None | 100 mg/kg-day | NOAEL (rat) | 100 mg/kg-day | None | 100 mg/kg-day |
| | Acute, small mammal (mouse) | | 100 mg/kg-day | x 4.4[c] | 440 mg/kg-day | | 100 mg/kg-day | x 4.4[c] | 440 mg/kg-day |
| | Acute, carnivorous mammal (canid) | | 100 mg/kg-day | ÷5[c] | 20 mg/kg-day | | 100 mg/kg-day | ÷5[c] | 20 mg/kg-day |
| | Chronic, medium mammal (squirrel) | NOAEL (rat) | 5 mg/kg-day | None | 5 mg/kg-day | NOAEL (rat) | 5 mg/kg-day | None | 5 mg/kg-day |
| | Chronic, small mammal (mouse) | | 5 mg/kg-day | x 4.4[c] | 22 mg/kg-day | | 5 mg/kg-day | x 4.4[c] | 22 mg/kg-day |
| | Chronic, carnivorous mammal (canid) | | 5 mg/kg-day | ÷5[c] | 1 mg/kg-day | | 5 mg/kg-day | ÷5[c] | 1 mg/kg-day |
| **Mammals – TCP** | | | | | | | | | |
| | Acute | NOAEL (rat) | 25 mg/kg-day | None | 25 mg/kg-day | NOAEL (rat) | 25 mg/kg-day | None | 25 mg/kg-day |
| | Chronic | NOAEL (rat) | 12 mg/kg-day | None | 12 mg/kg-day | NOAEL (rat) | 12 mg/kg-day | None | 12 mg/kg-day |
| **Birds – Triclopyr BEE, TEA or Acid** | | | | | | | | | |
| | Acute | NOAEL (BEE, quail) | 126 mg/kg-day | None | 126 mg/kg-day | NOAEL (BEE, quail) | 126 mg/kg-day | None | 126 mg/kg-day |
| | Reproductive (Chronic) | NOAEL (acid, mallard) | 7.5 mg/kg-day | None | 7.5 mg/kg-day | NOAEL (acid, mallard) | 7.5 mg/kg-day | None | 7.5 mg/kg-day |
| **Birds – TCP** | | | | | | | | | |
| | Acute and chronic | LOAEL (quail) | 116 mg/kg-day | None[a] | 116 mg/kg-day | NOAEL (quail) | 116 mg/kg-day | ÷10 | 11.6 mg/kg-day |
| **Insects – Triclopyr BEE and Triclopyr Acid** | | | | | | | | | |
| | Honeybees | $LC_{50}$ | >72 (µg/bee) | ÷0.000116[d] | 620 mg/kg-day | $LC_{50}$ | >72 (µg/bee) | ÷0.000116[d] ÷20[e] | 31 mg/kg-day |
| **Terrestrial Plants, Sensitive Species – Triclopyr BEE** | | | | | | | | | |
| | Vegetative vigor | NOEC (BEE, sunflower) | 0.0028 lb/acre | None | 0.0028 lb/acre | NOEC (BEE, sunflower) | 0.0028 lb/acre | None | 0.0028 lb/acre |
| | Seedling emergence | NOEC (BEE, onion) | 0.02 lb/acre | None | 0.02 lb/acre | NOEC (BEE, onion) | 0.02 lb/acre | None | 0.02 lb/acre |
| **Terrestrial Plants, Sensitive Species – Triclopyr TEA or Acid** | | | | | | | | | |
| | Vegetative vigor | NOEC (TEA, sunflower) | 0.0028 lb/acre | None | 0.0028 lb/acre | NOEC (TEA, sunflower) | 0.0028 lb/acre | None | 0.0028 lb/acre |
| | Seedling emergence | NOEC (TEA, soybean) | 0.0028 lb/acre | None | 0.0028 lb/acre | NOEC (TEA, soybean) | 0.0028 lb/acre | None | 0.0028 lb/acre |

[a] The animal NOAEL was divided by an interspecies uncertainty factor of 10 and an intraspecies factor of 10, equivalent to dividing by 100. This is EPA's RfD.
[b] The animal NOAEL for TCP was used as the endpoint and was divided by an interspecies uncertainty factor of 10, an intraspecies factor of 10, and an FQPA factor of 10, equivalent to dividing by 1000. This is EPA's Population Adjusted Dose (PAD). See Section 4.2.1 for more discussion.
[c] The allometric relationship described in Section 4.3.1.J was used to estimate the NOAEL for a 20 gram mouse, which is approximately 4.4 times the NOAEL for a 400 gram rat. For a 10 kg canid, the NOAEL is about $1/5^{th}$ that for a 400 gram rat.
[d] The $LC_{50}$ of 100 µg/bee was converted to a dose in mg/kg by multiplying by the conversion factor between mg and µg (0.0001 mg/µg) and dividing by the USFS estimate of body weight of a bee: 0.000116 kg.
[e] The adjustment factors of 10 (mammals and birds) and 20 (terrestrial invertebrates and aquatic animals) are used by the US EPA in evaluation of endangered species effects when there is only an $LD_{50}$ or $LC_{50}$ value available, not the preferred NOAEL or NOEC. These factors are based on a review of literature studies in which both $LD_{50}$ or $LC_{50}$ and NOAEL or NOEC values were available for comparison.[24]

**Table 4-8: Comparison of Triclopyr and TCP TRVs Used in USFS and Mount Sutro Risk Assessments for Aquatic Organisms**

| | | USFS | | | | Mount Sutro | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Exposure Type** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in USFS Risk Assessment** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in Mount Sutro Risk Assessment** |
| **Sensitive Fish – Triclopyr BEE** | | | | | | | | | |
| | Acute | NOEC (BEE, bluegill) | 0.091 mg/L | None | 0.091mg/L | $LC_{50}$ (BEE, bluegill) | 0.091 mg/L | None | 0.091 mg/L |
| | Chronic | NOEC (BEE, rainbow trout) | 0.019 mg/L | None | 0.019 mg/L | NOEC (BEE, rainbow trout) | 0.019 mg/L | None | 0.019 mg/L |
| **Sensitive Fish – Triclopyr TEA or Triclopyr Acid** | | | | | | | | | |
| | Acute | $LC_{50}$ (acid, silverside) | 40.1 mg/L | x0.5[a] | 20 mg/L | $LC_{50}$ (acid, silverside) | 40.1 mg/L | ÷20[c] | 2.0 mg/L |
| | Chronic | NOAEC (TEA, fathead minnow) | 20 mg/L | x0.37[b] | 7.4 mg/L | $LC_{50}$ (acid, silverside) | 40.1 mg/L | ÷20[c] | 2.0 mg/L |
| **Sensitive Fish – TCP** | | | | | | | | | |
| | Acute | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L |
| | Chronic | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L |
| **Sensitive Amphibians – Triclopyr BEE** | | | | | | | | | |
| | Acute | $EC_{10}$ (larvae) | 0.1 mg/L | None | 0.1 mg/L | $EC_{10}$ (larvae) | 0.1 mg/L | None | 0.1 mg/L |
| | Chronic | $EC_{10}$ (larvae) | 0.1 mg/L | None | 0.1 mg/L | $EC_{10}$ (larvae) | 0.1 mg/L | None | 0.1 mg/L |
| **Sensitive Amphibians – Triclopyr TEA or Triclopyr Acid** | | | | | | | | | |
| | Acute | NOAEC | 125 mg/L | None | 125 mg/L | NOAEC | 125 mg/L | None | 125 mg/L |
| | Chronic | NOAEC | 125 mg/L | None | 125 mg/L | NOAEC | 125 mg/L | None | 125 mg/L |
| **Sensitive Amphibians – TCP** | | | | | | | | | |
| | Acute | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L |
| | Chronic | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L | NOAEC (rainbow trout) | 0.18 mg/L | None | 0.18 mg/L |
| **Sensitive Aquatic Invertebrates – Triclopyr BEE** | | | | | | | | | |
| | Acute | NOAEC (Daphnia) | 0.045 mg/L | None | 0.045 mg/L | NOAEC (Daphnia) | 0.045 mg/L | None | 0.045 mg/L |
| | Chronic | LOAEC (Simocephalus) | 0.25 mg/L | None | 0.25 mg/L | NOAEC (Daphnia) | 0.045 mg/L | None | 0.045 mg/L |

| | | USFS | | | | Mount Sutro | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Exposure Type** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in USFS Risk Assessment** | **Selected Endpoint** | **Dose** | **Adjustments to Dose** | **TRV Used in Mount Sutro Risk Assessment** |
| **Sensitive Aquatic Invertebrates – Triclopyr TEA or Triclopyr Acid** | | | | | | | | | |
| | Acute | NOAEC (Daphnia) | 25 mg/L | None | 25 mg/L | NOAEC (Daphnia) | 25 mg/L | None | 25 mg/L |
| | Chronic | NOAEC (Daphnia) | 25 mg/L | None | 25 mg/L | NOAEC (Daphnia) | 25 mg/L | None | 25 mg/L |
| **Sensitive Aquatic Invertebrates – TCP** | | | | | | | | | |
| | Acute | $LC_{50}$ (Daphnia) | 10.9 mg/L | ÷20[c] | 0.55 mg/L | $LC_{50}$ (Daphnia) | 10.9 mg/L | ÷20[c] | 0.55 mg/L |
| | Chronic | NOEC (Daphnia) | 0.058 mg/L | None | 0.058 mg/L | NOEC (Daphnia) | 0.058 mg/L | None | 0.058 mg/L |
| **Aquatic Plants – Triclopyr BEE** | | | | | | | | | |
| | Algae, sensitive | $EC_{50}$ | 0.0014 mg/L | [d] | 0.0014 mg/L | $EC_{50}$ | 0.0014 mg/L | [d] | 0.0014 mg/L |
| | Algae, tolerant | $EC_{50}$ | 1 mg/L | [d] | 1 mg/L | $EC_{50}$ | 1 mg/L | [d] | 1 mg/L |
| **Aquatic Plants – Triclopyr TEA or Acid** | | | | | | | | | |
| | Algae, sensitive | $EC_{50}$ | 0.23 mg/L | [d] | 0.23 mg/L | $EC_{50}$ | 0.23 mg/L | [d] | 0.23 mg/L |
| | Algae, tolerant | $EC_{50}$ | 4 mg/L | [d] | 4 mg/L | $EC_{50}$ | 4 mg/L | [d] | 4 mg/L |
| **Aquatic Plants – TCP** | | | | | | | | | |
| | Algae, sensitive | $EC_{50}$ | 0.36 mg/L | [d] | 0.36 mg/L | $EC_{50}$ | 0.36 mg/L | [d] | 0.36 mg/L |
| | Algae, tolerant | $EC_{50}$ | 0.65 mg/L | [d] | 0.65 mg/L | $EC_{50}$ | 0.65 mg/L | [d] | 0.65 mg/L |

[a] The USFS adjusted the $LC_{50}$ by a factor of 0.5 to estimate a surrogate acute NOAEC, based on the ratio of $LC_{50}$ to NOAEC reported for fish in another study. See Section 4.3.3.1 in reference 6.

[b] The USFS adjusted the $LC_{50}$ by a factor of 0.37 to estimate a surrogate chronic NOAEC, based on the ratio of $LC_{50}$ to NOAEC reported for fish in another study. See Section 4.3.3.1 in reference 6.

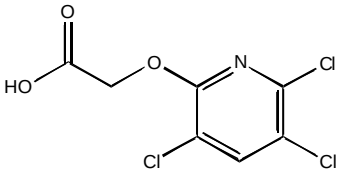
[c] The adjustment factors of 10 (mammals and birds) and 20 (terrestrial invertebrates and aquatic animals) are used by the US EPA in evaluation of endangered species effects when there is only an $LD_{50}$ or $LC_{50}$ value available, not the preferred NOAEL or NOEC. These factors are based on a review of literature studies in which both $LD_{50}$ or $LC_{50}$ and NOAEL or NOEC values were available for comparison.[24]

[d] The USFS adjusted the $EC_{50}$ values to NOECs using a statistical analysis described in Sections 4.3.3.4.1.2.1 and 4.3.3.4.1.2.2 in reference 6.

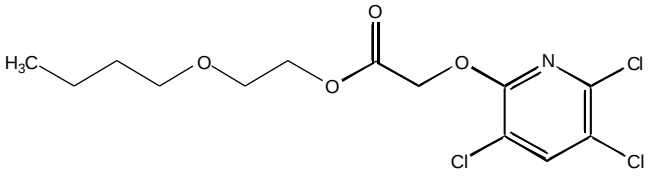
## 4.4 Environmental Fate of Triclopyr

### 4.4.1 Overview

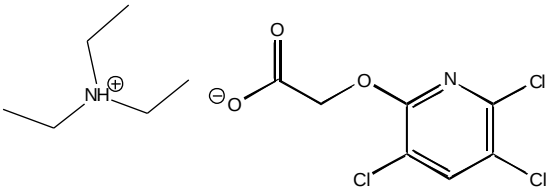
Triclopyr acid (CAS number 55335-06-3) is a chloropyridinyl herbicide, with empirical formula of $C_7H_4Cl_3NO_3$. The chemical structure is shown below. Triclopyr is usually formulated as an amine salt or as an ester of the carboxylic acid; the Garlon 4 Ultra product selected for consideration by UCSF contains the butoxyethyl ester of triclopyr (CAS number 64700-56-7). Once in an aqueous environment, esters of triclopyr hydrolyze fairly rapidly and react similarly to triclopyr itself, thus studies of both triclopyr and triclopyr salts and esters are reviewed. Table 4-9 summarizes the chemical and physical properties of triclopyr.




Triclopyr acid

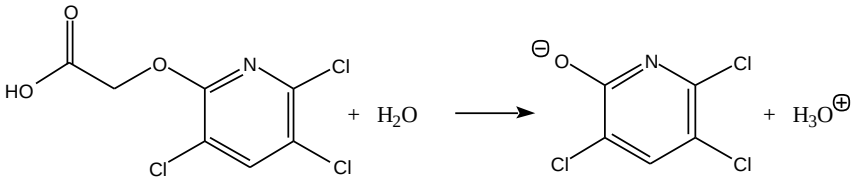



Triclopyr butoxyethyl ester




Triclopyr triethylamine salt

Triclopyr is a weak organic acid, with pKa of 2.93.[93] In a saturated aqueous solution of triclopyr (concentration of 430 mg/L), the acid is almost completely dissociated to form the triclopyr anion and acid ($H_3O^+$). The pH of this solution is quite acidic, at 2.77.




Triclopyr acid Triclopyr anion

**Table 4-9: Chemical and Physical Properties of Triclopyr**

| Property | Triclopyr acid | Triclopyr TEA | Triclopyr BEE | TCP |
|---|---|---|---|---|
| **CAS number** | 55335-06-3 | 57213-69-1 | 64700-56-7 | 6515-38-4 |
| **EPA PC code** | 116001 | 116002 | 116004 | 206900 |
| **Molecular weight (g/mol)** | 256.5 | 357.6 | 356.7 | 198.6 |
| **Water solubility (mg/L at ~25°)** | 430 | 234,000 | 6.8 | 44,000 (≥ pH 7) |
| **Half-life (days)** | | | | |
| **Hydrolysis** | -- | -- | 0.5 (pH 6.7) | 270 |
| **Anaerobic** | 1,600 | 1,600 | 26.4 | -- |
| **Aerobic** | 12.8 | 12.8 | -- | 129 (10°C) |
| **Field dissipation** | 139 | 139 | 39 | 8–96 |
| **Vapor pressure (mm Hg at ~25°C)** | $1.26 \times 10^{-6}$ | $< 1 \times 10^{-8}$ | $3.6 \times 10^{-6}$ | -- |
| **$K_{oc}$ (mL/g)** | 19–78 | 24–144 | 6,000 | 14–86<br>0.53–1.95 |
| **$K_{ow}$** | 0.205 | 1.23 | $1.2 \times 10^{4}$ | -- |
| **$K_H$ (atm-m$^3$/mol at ~25°C)** | $9.65 \times 10^{-10}$ | $6.0 \times 10^{-7}$ | $2.47 \times 10^{-7}$ | -- |

*Data source:* References 10, 93, and 105.

### 4.4.2 Water Solubility and Soil Binding of Triclopyr

The parent acid triclopyr is a solid at room temperature and has moderate water solubility (430 mg/L at 25°C). The TEA salt of triclopyr has much higher water solubility (234,000 mg/L at 25°C) and the BEE derivative is relatively insoluble (6.81 mg/L at 25°C). The octanol-water partition coefficient, $K_{ow}$, for triclopyr BEE is $1.2 \times 10^4$ indicating low solubility in water relative to organic solvents and some potential for bioaccumulation, although because the half-life of triclopyr BEE is quite short, bioaccumulation is unlikely to occur to a significant extent. The $K_{ow}$ for triclopyr TEA is much lower at 1.23, indicating low potential for bioaccumulation.

The organic-carbon-adjusted soil adsorption coefficient ($K_{oc}$) of triclopyr acid is 19–78 mL/g, a value that indicates that, in a mix of soil and water, most triclopyr remains dissolved in water rather than bound to organic matter in soil. This property makes triclopyr acid mobile in soils. Triclopyr BEE has a much higher $K_{oc}$ at 6,000 cm$^3$/g; it adsorbs to plants in aqueous systems and organic matter in soils, but is rapidly transformed to the acid.

### 4.4.3 Persistence of Triclopyr

Triclopyr BEE degrades rapidly in both water and soil to triclopyr acid, with a half-life of approximately 0.5 days in water and 3 hours in soil, with hydrolysis rates increasing at higher pH. In water, both hydrolysis and photolysis contribute to the degradation process. In soils, microbial activity contributes to the degradation process, with rate increases observed when temperature and moisture content of the soil are high. The TEA salt dissolves to form the salt of the acid. Triclopyr acid is stable to hydrolysis, with photolysis the primary route of degradation in water. Photolysis does not contribute significantly to degradation in soils.

Triclopyr acid degrades to form 3,5,6-trichloro-2-pyridinol (TCP) and 3,5,6-trichloro-2-methoxypyridine (TMP) under aerobic conditions. In a lab soil-column study, the relative amounts of these products at 54 days were 4% triclopyr, 81% TCP, and 15% TMP for triclopyr acid-treated soil. For triclopyr BEE-treated soils, concentrations were 6% triclopyr, 88% TCP

and 7%TMP.[94] Triclopyr acid and TCP are both moderately persistent in the environment. On average, the half-life of triclopyr acid is 11–100 days in temperate climates; in cold climates, half-lives range from 365–720 days. The transformation products TCP and TMP are more persistent, with half-lives of 12–229 days for TCP and 50-450 days for TMP.[93] Table 4-10 provides half-lives for specific studies under a variety of different conditions, and some of the more relevant studies are summarized briefly below.

The dissipation half-life of triclopyr in water is less than a laboratory-measured half-life. In a recent study by the San Francisco Estuary Institute, a creek was treated with triclopyr TEA.[106] During the hours following the application, triclopyr concentrations were measured at 6.65–250 µg/L, below the TRVs for several reference species. Several days after the application, the concentration was 12 µg/L. Another study evaluated the fate of triclopyr BEE in streams by directly injecting triclopyr BEE into a stream at a concentration equivalent to an application rate of 3.6 lb a.i./acre.[107] The highest concentrations of triclopyr BEE were found in leaf packs of degraded hardwood foliage that had been placed in the stream. Within hours, triclopyr BEE in the water had degraded to triclopyr acid; degradation in the leaf packs was slower. Residues of triclopyr acid in the sediments were ten times lower than those in the water, but remained longer.

Compared to aqueous half-lives, soil dissipation half-lives of triclopyr are substantially longer, (see Table 4-10). For many of these studies, only triclopyr residues were monitored, and the primary degradation product TCP was not measured. The National Marine Fisheries Service (NMFS) released a Biological Opinion in November 2008 for salmonid exposure to several organophosphorus pesticides and their degradation products, one of which is TCP. The NMFS noted that substantial amounts of TCP remain in the environment at 365 days post-application, which can run off into surface waters. The solubility and $K_{oc}$ values are similar between triclopyr and TCP, indicating that runoff potential is similar for the two compounds.[108]

**Table 4-10: Half-Life of Triclopyr Acid, Butoxyethyl Ester (BEE), and Triethylamine Salt (TEA)**

| Conditions | Half-Life (days) | Type of Half-Life | Comments | Reference |
|---|---|---|---|---|
| **Water: Triclopyr acid** | | | | |
| Laboratory | 142 | Aerobic | Does not adsorb to suspended solids or organic matter | 109 |
| Laboratory | Stable | Hydrolysis | Acid is stable with respect to hydrolysis | 110 |
| | 4.7 mos | Aerobic dissipation | Degradation to TCP | 111 |
| Anaerobic | 3.5 years | Anaerobic dissipation | Degradation to TCP | 112 |
| Lab | 270 | Hydrolysis | | 113 |
| Natural water | 1.3 | Photolysis | | 114 |
| **Water: Triclopyr triethylamine salt** | | | | |
| Natural water, 25°C, pH 6.7 | 0.5 | Hydrolysis | TEA dissolves to form the acid. | 115 |
| River water, 25°C, pH 8.5 | 0.713 | Photolysis | Hydrolysis half -life | 116 |
| Buffer solution, 25°C, pH 7 | 0.357 | Photolysis | Hydrolysis half -life | 116 |
| Whole pond application in CA, MS, and TX: | | Field dissipation | Dissipation of triclopyr and metabolites is similar in the different states. | 117 |
| In water | 5.9-7.5 | | | |
| In sediment | 2.8-4.6 | | | |
| **Water: Triclopyr BEE** | | | | |
| Laboratory: 15°C, pH 5 | 209 | Hydrolysis | | 116 |
| Laboratory: 25°C, pH 5 | 165 | Hydrolysis | | 116 |
| Laboratory: 25°C, pH 5 | 84 | Hydrolysis | | 116 |
| Laboratory: 25°C, pH 5 | 84 | Hydrolysis | | 116 |
| Laboratory: 35°C, pH 5 | 25.9 | Hydrolysis | | 116 |

| Conditions | Half-Life (days) | Type of Half-Life | Comments | Reference |
|---|---|---|---|---|
| **Soil: Triclopyr acid** | | | | |
| Reported range in soil | 12-27 | | | 113 |
| Cold climate | 365-730 | | | 118 |
| Silty clay loam | 8 | Aerobic | | 109, 110 |
| Silt loam | 18 | | | |
| Anaerobic conditions | 1,300 | Anaerobic | | 109 |
| Aerobic conditions | 32 | Aerobic | Average | 110 |
| Silt-loam | 69 | Aerobic | | 110 |
| MS | 43 | Field dissipation | | 110 |
| CA, grass | 36 | Field dissipation | | 110 |
| CA, bare soil | 35 | Field dissipation | | 110 |
| Nova Scotia | 15 | Field dissipation | | 110 |
| Ontario | 26 | Field dissipation | | 110 |
| **Soil: Triclopyr BEE** | | | | |
| Not reported | 3 hr | Aerobic hydrolysis to acid | | 119 |
| Not reported | 1 | Anaerobic hydrolysis to acid | | 119 |
| Not reported | 26.45 | Anaerobic | | 120 |
| Not reported | 39 | Field dissipation | | 120 |
| Gorse and pasture grass | 107 | Field dissipation | Soil sampled from sheltered sites beneath bushes | 121 |
| Gorse and pasture grass | 97 | Field dissipation | Soil from exposed sites at least 3m away from bushes | 121 |
| Clear-cut site in both exposed & unexposed soil | 96.0 ± 9.9 | Field dissipation | Average value. Half-life in unexposed soil was less than half-life in exposed soil | 122 |
| Forest sites (soil and litter): | 10 | Field dissipation | | 123 |
| Right of way in Ontario, Canada (soil and grass): | 20 | | | |
| Southwest OR | 11-25 | Field dissipation | | 124 |
| 25°C, pH 5.7, sandy loam | <0.5 | Anaerobic | | 125 |
| 25°C, pH 6.3, sandy loam | 88.6 | Anaerobic | | 116 |
| 25°C, pH 5.3, loam | 39 | Field dissipation | | 116 |
| 25°C, pH 5.7, sandy loam | 16.2 | Anaerobic | | 116 |
| 25°C, pH 6.3, sandy loam | 63.8 | Anaerobic | | 116 |
| **Soil: Triclopyr, TEA salt** | | | | |
| Southwest OR | 11-25 | Field dissipation | | 124 |
| | 12.8 | Aerobic | | 120 |
| | 139 | Field dissipation | | 120 |
| | 1,600 | Anaerobic | | 120 |
| 25°C, pH 6.6, silty loam | 17.7 | Aerobic | | 116 |
| 25°C, pH 5.2, silty clay | 7.8 | Aerobic | | 116 |
| 25°C, pH 5.7, sandy loam | 1,300 | Anaerobic | | 116 |
| 23°C, pH 7.5, loam | 85.3 | Soil | | 116 |
| 25°C, pH 6.3, sandy loam | 1,900 | Anaerobic | | 116 |
| **Air: Triclopyr acid** | | | | |
| | >12 hr | Photolysis | Exists in both vapor and particulate phase | 109 |
| | 3.3 | | Reacts with hydroxyl radicals | 109 |

Triclopyr can be transported away from an application site or degrade in soil, water and air through a number of different chemical or biological processes. The most important processes for dissipation of triclopyr are microbial biodegradation, runoff into surface waters, uptake by plants, and photodegradation in water. Figure 4-5 describes the various degradation pathways for triclopyr.

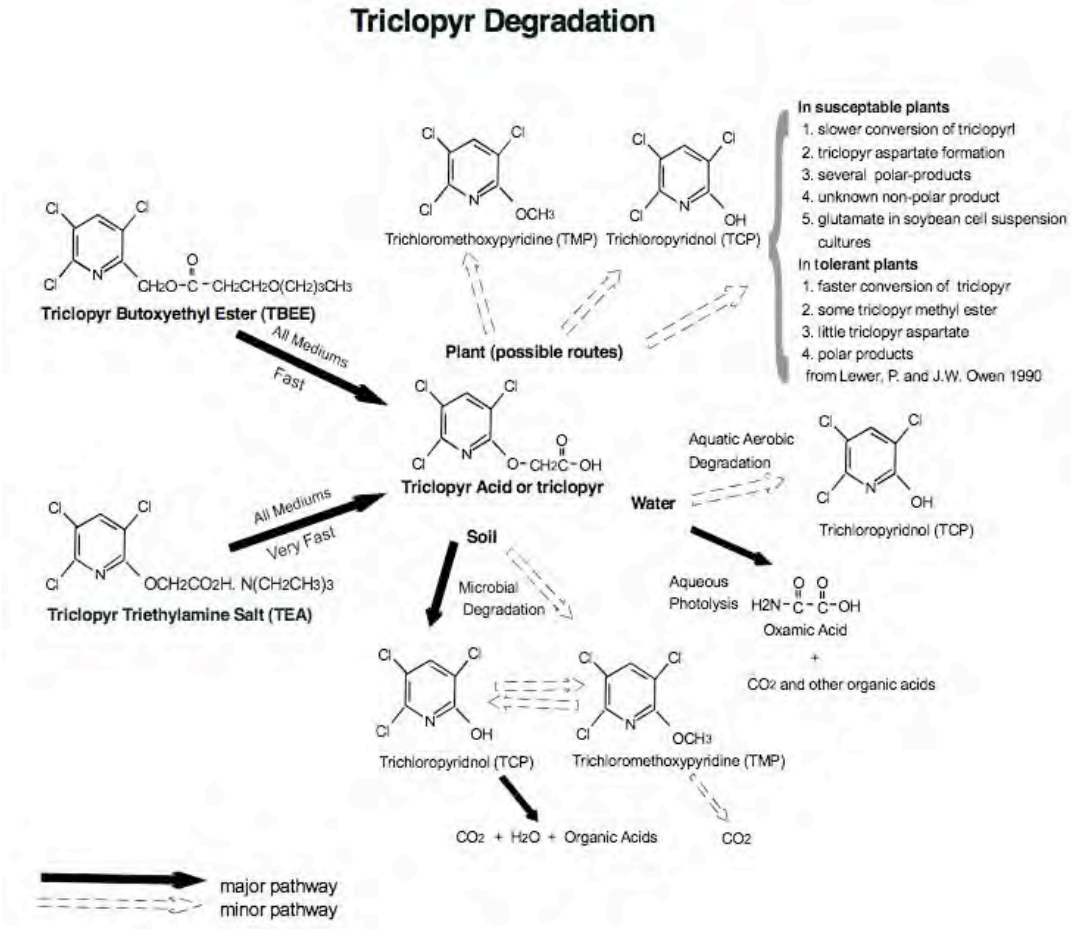



**Figure 4-5:** Degradation pathways for triclopyr. (Schematic excerpted from reference 93).

### *4.4.3.A Microbial Degradation*

The primary route of triclopyr degradation in the environment is via microbial degradation in soil.[93] Under aerobic conditions, 3,5,6-trichloropyridinol (TCP) is the primary degradation product. Further degradation yields carbon dioxide, water and organic acids. Microbial activity increases with higher temperatures and moisture levels. TCP degrades more slowly than triclopyr and is similarly water-soluble.

### *4.4.3.B Transport by Air*

Air transport of triclopyr away from the application site can occur through spray drift during and for a short time after an application. Spray drift can contaminate soil and surface waters, damage non-target plants, and expose humans and wildlife through inhalation and dermal exposure. Damage to plants from off-target movement of triclopyr can be significant.[126] Post-application volatilization drift is not a significant source of off-site transport for triclopyr acid or BEE because of their low vapor pressures ($1.26 \times 10^{-6}$ mm Hg and $3.6 \times 10^{-7}$, respectively at 25°C),

although volatilization can still contribute significantly to toxicity to non-target plants, even at the low concentrations anticipated from volatilization. Similar effects have been observed for the herbicide propanil (vapor pressure = 6.4 x $10^{-7}$ mm Hg at 25°C), resulting in restrictions on its use in California during certain times of the year because of damage to prune trees.[127]

When dissolved in water, triclopyr TEA or BEE do not appreciably escape to the air, as indicated by their very low Henry's law constants of 9.65 x $10^{-10}$ atm-$m^3$/mol and 2.47 x $10^{-7}$ atm-$m^3$/mol, respectively.

#### *4.4.3.C Transport by Water*

Triclopyr acid and TEA salt are considered to be mobile in soils because of their low $K_{oc}$ values and high water solubility. Triclopyr BEE is less mobile, but rapidly breaks down to form triclopyr acid. Triclopyr sorption to soils seems to increase with time, decreasing its mobility.[128] In laboratory studies of soil leaching, little downward mobility of triclopyr was noted, and most of the applied herbicide stayed in the top 10 cm of soil.[129] Triclopyr runoff from soil surfaces was also not found to be a major contributor to surface water contamination, with runoff samples containing less than 1 µg/L triclopyr from one to 105 days after treatment at 2.7 lbs a.i./acre.[130] The breakdown products appear to be relatively immobile as well.[131] Most of the TCP is expected to stay in the top one to two inches of soil.[132]

Other work indicates that there are conditions where substantial leaching of relatively immobile herbicides to groundwater occurs—when soil quality is poor, containing a high percentage of gravel and a low organic matter,[133] or in the presence of fractured soils.[134]

Although most of the field studies designed to measure triclopyr water contamination indicate that triclopyr will not run off in substantial amounts, actual monitoring data indicate that triclopyr contamination of waterways is occurring. USGS water sampling through the National Water Quality Assessment Program (NAWQA) found that nationally, 6.4% of 4,435 surface water samples tested positive for triclopyr.[135] In Oregon, where triclopyr is used more heavily in forestry applications, 47% of the 139 samples contained detectable triclopyr, with a maximum concentration of 2.87 µg/L. In California, where triclopyr is used on flooded rice fields that drain to surface waters, the maximum level detected is slightly higher at 3.35 µg/L, and 11.5% of 227 samples contained detectable triclopyr. Since the NAWQA monitoring program is not targeted at specific applications or storm events, it is unlikely that a true maximum concentration was observed.

#### *4.4.3.D Uptake by Plants*

Plants treated with triclopyr absorb the chemical though foliage, roots or cut stems of a plant. Foliar uptake is rapid, with 90% of applied triclopyr taken up within 12 hours.[93] Surfactants increase the rate of uptake from foliage and stems. While root uptake is possible, foliar sprays are more effective for herbicidal treatments.

Triclopyr residues can persist in dead plant stems. In one study, levels of triclopyr up to 0.9 ppm were detected in dead stems after 22–26 months.[136] Another study evaluated triclopyr residues in animal feed.[137] One year after treatment, residues ranging from 0.2–6.7 ppm were measured. It was estimated that residues decreased by 42 percent in six days, 72 percent after 28 days and 98

percent after 365 days. Two similar studies by Dow[138] gave similar results, with estimated half-lives on vegetation of four to ten days. TCP was also measured, with the highest levels at 20 ppm, decreasing to non-detects. Overall, dissipation of triclopyr from plant tissue is slower than dissipation in soils. There is also reason to believe that foliar dissipation of triclopyr is longer than glyphosate. A comparison of glyphosate and triclopyr residues in sugar maple (*Acer saccharum*) foliage suggests that triclopyr acid persists longer (90 percent dissipation in 33 days) than glyphosate (90% dissipation in 16 days). Dissipation of these pesticides from dead foliage was not explicitly discussed.

#### *4.4.3.E Field Studies on the Environmental Fate of Triclopyr*

A number of field studies have been conducted on the environmental fate of triclopyr. Those most relevant to the Mount Sutro site are reviewed here. Summaries of additional studies can be found in references 6 and 93.

**Fate in soils:** One study commissioned by Dow has relevant information to application on Mount Sutro.[139] A clear-cut forestry site was treated with triclopyr BEE at 6.0 lb a.i./acre by helicopter, using buffer zones around the stream. Vegetation and soil samples were collected over time and analyzed for triclopyr, TCP and TMP. Only small quantities of the breakdown products were detected, compared with triclopyr. In one plot, TCP and TMP concentrations were about 0.57 and 0.29 percent of the triclopyr BEE applied, respectively. The half-life of triclopyr in vegetation was determined to be 15±9 days. The dissipation half-life of triclopyr in litter was determined to be 20±6 days. Data collected from soil samples indicated that triclopyr remained mainly in the top 6 inches of soil. Even in the exposed soil areas, which represent a worst-case scenario, only a fraction of the percent applied was detected at soil intervals below 24 inches at six months after treatment. The average soil half-life for triclopyr was 96.0±9.9 days. The half-life of triclopyr in unexposed soil was shorter than in exposed soil.

Another study provided information on triclopyr concentrations in soil, vegetation and litter after an application of both triclopyr TEA and BEE to brush in Southwest Oregon at 2.0–3.9 lb a.i./acre for the salt and 1.5–2.9 lb a.i./acre for the ester.[140] At 37 days after application, 24 to 51 percent of the applied triclopyr was present in the surface soil. The soil was dry, as no rain had occurred during that period. From 37 to 79 days, the largest decrease in soil residues occurred. This coincided with a warm, moist period when the half-life ranged from 11 to 25 days. The herbicide concentration decreased more slowly during the winter. In the spring, the decrease in residues resumed, due to increased soil temperatures and microbial activity. The researchers found that triclopyr was practically immobile in soil-water and therefore would only move a short distance in forest subsurface flow. The half-life in litter was 31–59 days. TCP and TMP levels were not reported.

**Fate in streams:** In a 1991 New Zealand study triclopyr levels were measured in stream runoff after an application to gorse and pasture grass treated with 3.5 lb a.i./acre of triclopyr BEE.[141] Samples were collected continuously for six months after treatment. The highest concentration of triclopyr was detected on the third sampling event following the first major rainstorm since the application at 41 to 46 days after treatment. Samples collected after that time yielded no detections, suggesting that the first substantial rainfall caused runoff of most of the available triclopyr. The total mass of the triclopyr in the stream water was calculated to be about 103 g or

equal to about 2.9 percent of the total triclopyr applied. TCP was not measured in this experiment. Adsorption of triclopyr to stream sediments and uptake by aquatic plants may have removed some of the herbicide from the water, suggesting that actual runoff rates might be higher. Triclopyr was not detected 400 m downstream of the sampling point. Soil samples from the treated site were also analyzed; half-lives of 107 days in sheltered sites and 97 days in exposed sites were determined. The researchers also noted that soil temperature and the amount and type of organic matter affect the persistence of triclopyr.

In a study on removal of invasive fig trees, Holmes and Berry[142] used basal bark treatments on densely spaced trees, demonstrating that such treatments can lead to annual application rates three to five times greater than the label limit on a per-acre basis. They used a solution of 25 percent triclopyr herbicide and 75 percent methylated seed oil to treat freshly cut fig stumps. While the treatment was effective, they found high residues of triclopyr (up to 6.6 ppm) near the treated stems six months after the treatment. The soil concentrations of triclopyr dropped off with distance, decreasing from an average of 3.2 ± 0.8 ppm within 0.5 meters of the treated area to 0.28 ± 0.09 ppm at distances between 0.5 meters from the treated area and the edge of the canopy dripline. These residues were sufficient to inhibit the survival of native plants transplanted into the treated area nearly six months after treatment, with 16 percent mortality observed in the treated areas, compared to zero percent for the untreated control site.

Region 5 (Pacific Southwest) of the USFS has conducted water quality monitoring after herbicide use in reforestation or invasive plant management in the Eldorado and Stanislaus National Forests between 1991 and 1999.[143] Triclopyr was monitored in five of these studies, both immediately after application to detect any spray drift into waterways and during the first runoff event, typically 60–90 days after the application. A buffer zone of at least 10 feet between streams and waterways was utilized, except for ephemeral streams. Out of 43 total water and sediment samples taken for the eight projects, 13 detections of triclopyr were noted, 12 less than 10 µg/L and one sample at 82 µg/L. The presence of triclopyr in the waterways was attributed to an insufficient buffer zone (less than 20 feet) during the applications. The degradates TCP and TMP were not analyzed.

**Fate in lentic systems:** A 2002 study in Minnesota tracked the fate of triclopyr applied directly to the shallow (1-2 m) part of a lake, using a red dye as a tracer.[144] Exact concentrations of triclopyr were not reported, but extrapolation from plots of the data indicate that triclopyr concentrations decreased from just less than 4.0 mg/L after the application to less than 0.1 mg/L 14 days later. Levels of TCP were also measured and found to be approximately 0.021 mg/L at the start of the application, declining to approximately 0.001 mg/L by day 21. The researchers explained the high TCP levels at the start of the application by noting that some TCP is present in triclopyr products. Another interesting observation made in this study was that the concentration of triclopyr in the surface layer of a lake where just the surface was treated (mimicking a helicopter or direct spray application, instead of an injection) was seven times higher than that in the deeper water, and concentration did not become uniform until five days after the application. The experimental section did not specify the sampling depth.

A 1996 Dow study evaluated triclopyr, TCP and TMP dissipation rates in water, sediments and fish in a closed whole-pond system over a 12-week period.[117] The target concentration for the

application was 2.5 mg a.e./L. The half-life of triclopyr in water ranged from 5.9–7.5 days, the TCP half-life was 4–8.8 days, and TMP was 4–10 days. The sediment half-life of triclopyr was shorter, at 2.8–4.6 days; for TCP, the sediment half-life was 3.8–13.3 days. TMP was not detected in the sediment. Concentrations of triclopyr and TCP in fish matched those in the water column, but TMP concentrations were typically an order of magnitude higher, particularly in the visceral portion of the animals. No adverse effects were observed on the non-target biotic community.

In 2009, USGS looked specifically at triclopyr concentrations in vernal pools used by amphibians for breeding in National Parks near application sites for invasive vegetation management projects, using foliar and cut-stump application methods.[145] The authors found triclopyr at concentrations of 0.00073 mg/L in a pond near a cut-stump treatment site 13 months after treatment. The concentration of triclopyr would likely have been significantly higher in the first-flush runoff from the site.

### 4.4.4 Garlon 4 Ultra Product Profile

The Garlon 4 Ultra product has been selected as one of the herbicides to be considered by UCSF for possible use on Mount Sutro. Garlon 4 Ultra (US EPA reg # 62719-527) contains the butoxyethyl ester (BEE) salt of triclopyr as the active ingredient (a.i.) at 43.6% weight percent, with the remaining 56.4% percent containing unspecified inert ingredients.[146] The product contains 6.28 kg/L (5.58 lbs/gal) of the a.i., which is equivalent to 4.5 kg/L (4 lbs/gal) of the acid equivalent (a.e.) of triclopyr.[147]

When applied as a foliar spray, Garlon 4 Ultra is mixed at 0.5-7.5% by volume in aqueous solution with a surfactant added to aid penetration of the a.i. through the waxy cuticle of the plant surface. The label recommends that Garlon 4 Ultra be used full-strength or diluted one part triclopyr to three parts water and/or surfactant for cut-stump treatments; however, research on the efficacy of triclopyr in cut-stump applications demonstrates comparable efficacy at concentrations as low as 3.3 percent solutions of product (see Section 2.1.1). The maximum label application rate to brush and forests is 1.5 gallons of product per acre per year and 6.75 kg/ha, and 9 kg/ha for perennial weeds. The maximum application rate that would be used by UCSF is 4 lb/acre. The label recommends use of no more than 1-2 quarts of surfactant per acre.

EPA has given this product an acute hazard warning label of “Caution,” placing it in Category 3 (Category 4 for inhalation exposure).[148] This rating means that the product is considered to be “Slightly toxic.” Exposure to skin or eyes may cause severe skin irritation and slight eye irritation.[149]

## *4.5 Exposure Assessment and Risk Characterization for Triclopyr*

Assessment of risk requires knowledge of both the inherent toxicity of a chemical and the amount of exposure that is anticipated based on intended uses. Risk characterization combines the hazard and exposure data to provide a picture of risks associated with herbicide use.

This risk characterization is presented for Demonstration Projects and for the Main Project, each described in the Notice of Preparation / Initial Study and summarized in Section 2.1.[150] Each section below reports differences, if any, in exposure and risk for the

Demonstration Projects in comparison to the full Main Project. As discussed in Section 2.1, doses are calculated on a per-acre basis in many cases. These per-acre dose values typically do not differ when comparing the full project to the demonstration projects, with limited exceptions discussed individually below.

This exposure analysis is divided into four categories: workers, general public, terrestrial wildlife, and aquatic life. Only one type of application is modeled for triclopyr: cut stump. The cut-stump applications proposed for triclopyr use higher concentrations of herbicide than foliar applications, such as that proposed for glyphosate (see Chapter 3). Cut-stump application rates of triclopyr are anticipated to be 1–4 pounds a.e. per acre. More information about the types of exposure scenarios considered in this risk assessment is available in Section 2.4. Toxicity reference values (TRVs) for triclopyr used in the analysis are discussed in Section 4.2 (humans) and Section 4.3 (animals and other organisms).

This risk assessment assumes compliance with the application guidelines and treatment schedule described in Section 2.5.1. The results described below are based on the maximum application rate under consideration for the Mount Sutro project, four pounds of triclopyr acid equivalent per acre on all of the 48 accessible acres in the reserve, which is designated as the Maximum Treatment scenario. The risks from this scenario and alternate treatment scenarios are summarized in the tables and charts in Sections 4.5.4 and 4.5.5 below. In total, the risks associated with four different scenarios were estimated:

1) Maximum treatment scenario: All accessible acres (48 total) treated at the maximum application rate of 4 lb a.e./acre;
2) Half-treatment scenario: Half the accessible acres (24 acres) treated at the maximum application rate or all of the acres treated at 2 lb a.e./acre; and
3) Quarter-treatment scenario: One-quarter of the accessible acres (12 acres) treated at the maximum application rate or all of the acres treated at 1 lb a.e./acre.
4) Demonstration project scenario: Demonstration Project area #4 treated at the maximum application rate of 4 lb a.e./acre.

The worksheets created by the Syracuse Environmental Research Associates (SERA) for the US Forest Service were used to calculate estimated triclopyr exposures and risks for workers, the general public, and terrestrial and aquatic wildlife.[151] Water contamination scenarios for accidental spills, peak runoff and long-term runoff into Woodland Creek; accidental spills into puddles/pools; and short-term runoff into San Francisco Bay and the Pacific Ocean were also evaluated (see Section 4.5.3 below). The details of how the exposures were calculated are discussed in Section 2.5.

Exposure scenarios were categorized qualitatively as "**Highly Probable**," "**Probable**," "**Possible**," "**Improbable**" and "**Highly Improbable.**" These five categories are used throughout the exposure estimates to designate the likelihood of each scenario occurring. Common scenarios and their probabilities are summarized in Tables 2-9 through 2-12 in Chapter 2. Assigned probabilities are based on the assumption that the application guidelines are followed.

For all of the different exposure scenarios, **Lower**, **Central** and **Upper** estimates were calculated for a given application rate. Central estimates were obtained using parameter values that are perceived as most realistic. Upper exposure estimates were calculated by changing all parameters to values that increase estimates, and Lower estimates were obtained by changing all parameters to values that decrease estimates, except for direct spray and accidental worker scenarios (see Section 2.5.3.A). The Central estimate is the best estimate of the most likely exposure. The Lower and Upper estimates provide a lower bound and a worst-case scenario that is less likely—and usually much less likely—than the Central estimate. More information about the types of exposure scenarios considered in this risk assessment is available in Section 2.5. Toxicity reference values (TRVs) used in the analysis for triclopyr are discussed in Section 4.2.2 (humans) and Section 4.3 (animals and other organisms).

**Hazard Quotients (HQs):** Exposure estimates for humans and wildlife are divided by human reference doses (RfDs) and wildlife toxicity reference values (TRVs) to give hazard quotients (HQs) that provide an estimate of risk from different exposure scenarios. (RfDs differ from TRVs by inclusion of uncertainty factors to account for inter- and intra-species variation.) Hazard quotients above 1.0 indicate that exposure exceeds the level of concern, and humans or wildlife may be at risk of adverse effects. These scenarios are flagged as potentially problematic and recommendations are made for how to avoid them. Hazard quotients between 0.1 and 1.0 suggest that particularly sensitive individuals or species may be affected. Hazard quotients below 0.1 indicate low levels of risk for the effects that have been studied and represented by the TRVs. In this document, hazard quotients less than 1.0 are reported as a percent of the TRV; HQs greater than 1.0 are reported as a multiplier of the TRV, e.g. “the HQ was 2.4 times the TRV.”

**Inerts and surfactants:** No assessment of risks could be performed for the unidentified “inert” ingredients in Garlon 4 Ultra—39.55 percent of the product by weight—some of which is a methylated seed oil of low toxicity, but not all ingredients are identified. Garlon 4 Ultra is usually mixed with a surfactant and a diluent such as diesel fuel prior to use. The toxicity of mixtures of triclopyr BEE with surfactant and diesel fuel is not fully known. See Chapter 5 for more discussion of surfactants.

### 4.5.1 Chemical-Specific Exposure Parameters

Many of the parameters used to estimate exposure are constant from chemical to chemical, e.g., typical amounts of food consumed, surface area of a child, and body weight, among others. These parameters and the values used in the exposure models are discussed in Section 2.5. Other parameters are chemical-specific—absorption coefficients and water contamination rates, for example—and are based on experimental data and/or physical properties such as water solubility, $K_{ow}$, vapor pressure, $K_{oc}$ and half-life. Triclopyr water contamination rates are discussed in more detail in Section 4.5.3 on Water Contamination Estimates below.

Table 4-11 presents the triclopyr-specific exposure parameters used in the calculations, including dermal absorption rates, half-lives, and triclopyr water contamination rates (discussed in more detail in Section 4.5.3). The parameters described in Table 4-11 would be equivalent for the Demonstration Projects and the Main Project because they are simply properties specific to triclopyr. As discussed in Section 2.5.3.A, USFS/SERA developed an estimate of dermal absorption rates based on $K_{ow}$ and molecular weight.[152] For triclopyr BEE, first-order absorption

rates were obtained in biomonitoring studies using human volunteers.[153] The empirical first-order absorption rate was found to be 0.031 hour$^{-1}$ with a 95 percent confidence interval of 0.0012–0.0081 hour$^{-1}$. Empirically measured rates were used for triclopyr BEE exposure estimates under first-order conditions, where only a limited amount of herbicide is spilled on the skin. The zero-order dermal exposure scenarios such as those for spills into gloves, where the herbicide is held against the skin, are derived from the estimated absorption rates because no empirical studies were available.

General worker exposure rates (in mg/kg per lb/acre applied) are derived from biomonitoring studies in workers.[154a-c] The methods used are discussed in Section 2.5.3.A. Urine concentrations of triclopyr following general exposure were varied from 0.003 to 0.03 mg/kg per lb a.i. handled, with a Central value of 0.012 mg/kg per lb a.i.

**Table 4-11: Triclopyr-Specific Exposure Parameters**

| Parameter | Lower Value | Central Value | Upper Value |
|---|---|---|---|
| First-order dermal absorption rate ($h^{-1}$) | 0.0012 | 0.0031 | 0.0081 |
| Dermal permeability (cm/hr) | 0.0066 | 0.013 | 0.026 |
| WCR, acute, triclopyr BEE (mg/L per lb/acre) | $1.5x10^{-7}$ | 0.0004 | 0.03 |
| WCR, chronic triclopyr BEE (mg/L per lb/acre) | NA | NA | NA |
| WCR, acute, triclopyr acid (mg/L per lb/acre) | $1.00x10^{-6}$ | 0.03 | 0.24 |
| WCR, chronic triclopyr acid (mg/L per lb/acre) | $8.16x10^{-12}$ | 0.00033 | 0.060 |
| WCR, acute, TCP (mg/L per lb/acre) | $1.00x10^{-8}$ | 0.0009 | 0.028 |
| WCR, chronic TCP (mg/L per lb/acre) | $1.22x10^{-13}$ | $1.67x10^{-5}$ | 0.0002 |
| Half-life as residue on food for triclopyr BEE and acid (days) | 16.5 | 26.9 | 73.1 |
| Half-life as residue in soil for triclopyr acid (days) | 26 | 38 | 69 |
| Half-life as residue in soil for TCP (days) | 26 | 38 | 69 |

WCR = water contamination rate. TCP = trichloropyridinol, the primary degradation product of triclopyr. NA = not available; the BEE compound is degraded rapidly, with little chronic exposure.
*Data source:* Reference 151. USFS worksheets C02, C03, B04, B02.

Triclopyr is proposed for use on Mount Sutro for cut-stump treatments at a maximum rate of 4 lb/acre. The application rates and volumes listed in Table 4-12 were used to calculate Lower, Central and Upper exposure estimates for workers, the general public, and terrestrial and aquatic wildlife. These were calculated for the four treatment scenarios: Maximum treatment, Half-treatment, Quarter-treatment and Demonstration projects. The cut-stump application scenario assumes that Garlon 4 Ultra is diluted until it is 5, 20 or 50 percent by volume.

**Table 4-12: Application Rate and Application Volume Model Inputs for Garlon IV Ultra**

| Parameter | Lower | Central | Upper |
|---|---|---|---|
| Application rate (lb a.e./acre) | 1 | 2 | 4 |
| Percent product (volume %) | 5% | 20% | 50% |
| Application volume (gallons) | 2 | 5 | 20 |

*Data source:* Reference 151.

### 4.5.2 Application Methods for Triclopyr

Cut-stump is the only application method being considered for triclopyr by UCSF. See Section 2.1.1 and 2.1.2 for a discussion of cut stump treatments. Cut-stump application involves cutting

the stem, and then spraying or painting Garlon 4 Ultra at 5–50 percent of the pure product on the cut stump surface.

Specific safety measures for applying triclopyr have been outlined by UCSF, in addition to the guidelines for all herbicide application. As stated in the Application Guidelines (Section 2.5.1.A), triclopyr application generally leads to higher human and wildlife doses than glyphosate due to its higher dermal permeability and higher aquatic toxicity. The following application guidelines are in place to minimize hazardous dermal exposures to triclopyr:

1. No applications of Garlon 4 Ultra will be conducted within 50 feet of a perennial or intermittent stream.
2. Two layers of gloves will be required for workers.
3. Backpack applicators that incorporate some form of physical separation between the backpack sprayer and the applicator are strongly recommended to prevent spills onto the applicator from a leaking backpack sprayer.

### 4.5.3 Water Contamination Estimates

Concentration estimates for several water contamination scenarios were calculated for triclopyr: accidental spill scenarios to puddles/pools and Woodland Creek, peak runoff and long-term runoff scenarios for Woodland Creek, and a short-term runoff scenario for the San Francisco Wastewater Treatment Plants (WWTPs). The spill scenarios typically include two spill volumes (one and 20 gallons) each for a spill of the cut stump solutions, with Central, Lower and Upper estimates based on the varying concentrations of the solutions. A 20-gallon spill of undiluted product to Woodland Creek was also assessed. See Section 2.5.2 for a detailed discussion of these scenarios. Results are shown in Table 4-13 below. The values in Table 4-13 are not equivalent for Demonstration Project 1 (South Ridge Area) compared to the Main Project because Demonstration Project 1 does not drain to Woodland Creek, but rather toward Christopher Drive to the southwest, where it is intercepted by the city stormwater system and carried to San Francisco's Oceanside Treatment Plant. Demonstration Project 4 (East Bowl Corridor) does drain to Woodland Creek; scenarios built for any treatment that drains to Woodland creek will apply equally to Demonstration Project 4.

Throughout this document, the word "contaminated" is used to mean that any amount of a chemical residue is present. "Contaminated" does not necessarily equate to hazardous, but indicates only that the herbicide is present at some level.

We used predicted triclopyr water contamination rates derived by USFS from several empirical monitoring studies.[155a-e] Peak concentrations in stream water (excluding accidental direct spray) were normalized to application rate, with a range of 0.033 to 0.11 mg a.e./L per lb a.e./acre. Empirical water contamination rates match GLEAMS modeling, which predicts 0.054-0.24 mg/L in a million liter pond after 50-100 inches of rain per year.

The topography of Mount Sutro ensures that stream flow will continue to dilute any herbicide washed off of treated areas; however, the available monitoring data suggests that local overland flow may wash glyphosate into puddles or pools on site, possibly resulting in concentrations above levels of concern. We did not model this scenario because we lacked the data to do so, but

note that concentrations will be higher in overland flow than in Woodland Creek. Risks to animals drinking out of puddles and to aquatic species using puddles for breeding habitat could be reduced by filling in ruts or depressions near treatment sites.

In estimating herbicide concentrations in Woodland Creek due to runoff, we used the USFS/SERA water contamination rates for the peak runoff scenario shown in Table 4-11 for triclopyr BEE, triclopyr acid and the degradation product TCP. The calculations for long-term runoff scenarios were adjusted for degradation of triclopyr over time and only assessed for triclopyr acid and TCP, since triclopyr BEE degrades within a few days to a few weeks. Starting with the chronic USFS water contamination rates, the chemical half-life in soil (see Table 4-11) was used to calculate the fraction of the chemical degraded during the 0–120-day window before the rainy season begins. See Section 2.5.2 for a detailed discussion of the methods used to estimate water contamination rates used in the USFS/SERA worksheets.

Predicted water contamination rates for glyphosate runoff to the Oceanside and Southeast WWTPs were estimated for the four treatment scenarios using USFS/SERA herbicide runoff rates from GLEAMS modeling. Runoff is variable, depending on climate and soil type, with the USFS/SERA method providing a range of scenarios to choose from. We used the scenario that most closely describes the Mount Sutro environment, as described below.

According to the 2001 Mount Sutro Open Space Management Plan, sandy loam soils predominate on the Reserve:[156]

> *In general, soils on Mount Sutro are thin, sandy material. The soil complex is mapped as Candlestick fine sandy loam—Kron sandy loam—Buriburi gravelly loam, on 30 to 75% slopes (SCS 1991). The constituent soil types of this complex are likely to occupy different areas. The Candlestick fine sandy loams are usually from 20 to 40 inches thick over bedrock, whereas the Buriburi gravelly loam and the Kron sandy loam are usually from 10 to 40 inches thick over bedrock. Many slopes have less than six inches of soil depth.*

Because San Francisco's climate is dry and temperate from approximately May through September and wet and cool during the rainy season from October through April, estimated glyphosate loss from runoff as a fraction of the application rate is presented in Table 3-14 for these two different site conditions and loam soils. Table 4-14 serves as only a rough estimate of runoff rates for Mount Sutro. The USFS/SERA worksheets (and hence the water contamination rates for the exposure estimates) do not incorporate site-specific characteristics such as the distance between the treatment site and the water body, the total number of acres treated, the volume of the receiving water bodies and the slope; instead, the calculations were based on a standard parameter set (described in Section 2.5.2.B and explicitly listed in Tables A09-1, A10-1, and A11-1 in USFS 2011[6]).

### Table 4-13: Calculated Triclopyr Concentrations for Water Contamination Scenarios on Mount Sutro

| Scenario | | Concentration (mg/L) Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|
| **Accidental Spill** (concentrations of triclopyr BEE spilled, at right) | | **20%** | **5%** | **50%** | |
| Accidental spill into a 5-100 Liter puddle/pool | | | | | |
| 1 gal | | 7,255 | 907 | 181,377 | HI / HI |
| Accidental spill into Woodland Creek, flowing at 2-10% of peak flow | | | | | |
| 1 gal | | 427 | 53 | 2,667 | HI / HI |
| 20 gal | | 8,535 | 1,067 | 53,346 | HI / HI |
| **Herbicide Runoff into Woodland Creek** | | **Central** | **Lower** | **Upper** | |
| **Maximum Treatment Scenario**[1] | | | | | |
| Peak runoff into Woodland Creek | | | | | |
| | Triclopyr BEE | 0.0016 | 6E-07 | 0.12 | **Pr / Pr** |
| | Triclopyr acid | 0.12 | 4E-06 | 0.96 | |
| | TCP | 0.0036 | 4E-08 | 0.11 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | | | | | |
| | Triclopyr acid | 0.0013 | 3E-11 | 0.24 | **Pr / Pr** |
| | TCP | 7E-05 | 5E-13 | 0.0080 | **Pr / Pr** |
| **Half-Treatment Scenario**[2] | | | | | |
| Peak runoff into Woodland Creek | | | | | |
| | Triclopyr BEE | 0.0008 | 3E-07 | 0.060 | **Pr / Pr** |
| | Triclopyr acid | 0.06 | 2E-06 | 0.48 | |
| | TCP | 0.0018 | 2E-08 | 0.056 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | | | | | |
| | Triclopyr acid | 0.0007 | 2E-11 | 0.12 | **Pr / Pr** |
| | TCP | 3E-05 | 2E-13 | 0.0040 | **Pr / Pr** |
| **Quarter-Treatment Scenario**[3] | | | | | |
| Peak runoff into Woodland Creek | | | | | |
| | Triclopyr BEE | 0.0004 | 2E-07 | 0.030 | **Pr / Pr** |
| | Triclopyr acid | 0.03 | 1E-06 | 0.24 | |
| | TCP | 0.0009 | 1E-08 | 0.028 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | | | | | |
| | Triclopyr acid | 0.0003 | 8E-12 | 0.06 | **Pr / Pr** |
| | TCP | 2E-05 | 1E-13 | 0.0020 | **Pr / Pr** |
| **Demonstration Project #4**[4] | | | | | |
| Peak runoff into Woodland Creek | | | | | |
| | Triclopyr BEE | 0.0005 | 2E-07 | 0.034 | **Pr / Pr** |
| | Triclopyr acid | 0.034 | 1E-06 | 0.27 | |
| | TCP | 0.0010 | 1E-08 | 0.032 | **Pr / Pr** |
| Long-term runoff into Woodland Creek | | | | | |
| | Triclopyr acid | 0.0004 | 9E-12 | 0.068 | **Pr / Pr** |
| | TCP | 8E-06 | 6E-14 | 0.0010 | **Pr / Pr** |

DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable; BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation produce of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.

[1] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[2] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[3] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[4] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

For homes that border the Reserve, the probability of herbicide-contaminated runoff entering private property is very low because for most of the watersheds on Mount Sutro (see Appendix B for a map of watersheds), rainfall runoff from the reserve is intercepted by roadside drainage culverts and routed to storm drains. Runoff from Watersheds Two and Four is the only runoff not captured by a storm drain. Watershed Two borders the back yards of 9-10 homes along the north end of Edgewood Avenue; however, as noted in the Application Guidelines in Section 2.5.1, herbicides would not be applied within 100 feet of the backyards along Edgewood Avenue or Christopher and Crestmont Streets. This 100-foot buffer zone extends beyond the western edge of Watershed Two, so no herbicides will be applied within this watershed at all, eliminating the possibility of herbicide transport to private property in this location. Watershed Four borders the Interior Greenbelt, owned by the City of San Francisco. Approximately two acres of this watershed are proposed for treatment with herbicides, which would result in an equivalent amount of herbicide in runoff as for Demonstration Project 4. Using the Upper runoff rate of 2.13% triclopyr BEE transported from two acres treated at 4 lb/acre results in a maximum estimated amount of herbicide loss of 0.17 lb (77 grams), distributed over the slope; the Central estimate is 0.026 lb (13 grams). Herbicide concentrations in runoff to private property bordering the Interior Greenbelt are anticipated to be substantially lower after the runoff has traversed the Interior Greenbelt property, with herbicides adsorbing to soil and leaf litter as they flow across the land. Ensuring that Watershed Four is treated early in the summer to provide as much time as possible for herbicide degradation to occur would reduce runoff further.

**Table 4-14: Percent of Herbicide Lost as a Function of Annual Rainfall and Soil Type**

| Site Conditions | Percent of Herbicide Lost on Loam Soils | | |
|---|---|---|---|
| | Lower | Central | Upper |
| **Triclopyr BEE runoff within one week** | | | |
| Dry and temperate | 0 | 0 | 0 |
| Wet and cool | 0.0036 | 0.32 | 2.13 |
| **Triclopyr acid long-term runoff** | | | |
| Dry and temperate | 0 | 0 | 0 |
| Wet and cool | 0.04 | 0.45 | 1.61 |
| **TCP long-term runoff** | | | |
| Dry and temperate | 0 | 0 | 0 |
| Wet and cool | 0.0124 | 0.043 | 0.27 |

*Data source:* Tables A09-1, A10-1, and A11-1 in the Appendices to the USFS Triclopyr Risk Assessment.[157]

Tables 4-15, 4-16 and 4-17 present modeled estimates of herbicide and herbicide degradation product concentrations at wastewater treatment plants after the 5-year storm, averaged over 24 hours of runoff. These concentrations are based on the number of acres treated, glyphosate runoff rate estimates from Table 4-14, and wet-weather capacities at San Francisco's Oceanside and Southeast wastewater treatment plants (see Section 2.5.2.H for a detailed discussion of the method of calculation). The four scenarios described above are modeled: Maximum treatment, Half-treatment, Quarter-treatment, and Demonstration plots. In addition, an estimated concentration of herbicide at Southeast WWTP was calculated should a 20-gallon spill to Woodland Creek occur during low to moderate flow conditions.

**Demonstration Projects and Herbicide Concentration at Wastewater Treatment Plants**: Because herbicide concentrations in runoff are proportional to acres treated, even treating the largest (two-acre) Demonstration Project, #4, would result in lower herbicide concentrations at WWTPs than the Main Project. The Upper estimates of triclopyr BEE concentration due to treatment at Demonstration Project #4 are 0.000024 and 0.000019 mg a.e./L, respectively.

**Table 4-15: Triclopyr BEE Concentrations at Wastewater Treatment Plants During the 5-Year Storm**

| Scenario | Acres Treated per Year at 4 lb/acre[1] | Max Lbs Triclopyr a.e. Applied Per Year[1] | WWTP In-plant Capacity (MGD) | Triclopyr BEE Concentration (mg/L) | | |
|---|---|---|---|---|---|---|
| | | | | Central | Lower | Upper |
| **Triclopyr BEE Runoff Rates[2] (at right)** | | | | 0.32% | 0.0036% | 2.13% |
| **Maximum Treatment Scenario[3]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 38.7 | 154.6 | 43 | 0.0001 | 2E-06 | 0.0009 |
| East Side watersheds (Southeast WWTP)[4] | 9.3 | 37.4 | 110 | 1E-05 | 1E-07 | 9E-05 |
| **Half-Treatment Scenario[5]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 19.3 | 77.3 | 43 | 7E-05 | 8E-07 | 0.0005 |
| East Side watersheds (Southeast WWTP)[4] | 4.7 | 18.7 | 110 | 7E-06 | 7E-08 | 4E-05 |
| **Quarter-Treatment Scenario[6]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 9.7 | 38.7 | 43 | 3E-05 | 4E-07 | 0.0002 |
| East Side watersheds (Southeast WWTP)[4] | 2.3 | 9.3 | 110 | 3E-06 | 4E-08 | 2E-05 |
| **Demonstration Projects 1 and 4[7]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 1 | 4 | 43 | 4E-06 | 4E-08 | 2E-05 |
| East Side watersheds (Southeast WWTP)[4] | 2 | 8 | 110 | 3E-06 | 3E-08 | 2E-05 |
| **Accidental 20-Gallon Spill into Woodland Creek** | | | | | | |
| East Bowl Corridor (DP 4, Southeast WWTP) | NA | 80 | 110 | 0.0087 | 0.0087 | 0.0087 |

MGD = million gallons per day. WWTP = wastewater treatment plant; Triclopyr BEE = triclopyr butoxyethyl ester.

[1] Acres treated and maximum pounds applied are per year were determined by the application guidelines and the treatment schedule. Pounds applied are given as acid equivalents, a.e. See Section 2.5.1.B for complete details.

[2] Triclopyr BEE runoff rate is the percent of applied triclopyr BEE that runs off of a treated area. Estimates based on USFS GLEAMS modeling are taken from Appendix 9, Table A09-1 in the USFS risk assessment.

[3] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[4] West side watersheds, which flow to Oceanside WWTP, are those numbered 1, 6, and 8–13 in Appendix B; East side watersheds, which flow to Southeast WWTP, are those numbered 2–5 and 7 in Appendix B.

[5] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[6] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[7] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

### Table 4-16: Triclopyr Acid Concentrations at Wastewater Treatment Plants During the 5-Year Storm

| Scenario | Acres Treated per Year at 4 lb/acre[1] | Max Lbs Triclopyr a.e. Applied Per Year[1] | WWTP In-plant Capacity (MGD) | Triclopyr Acid Concentration (mg/L) | | |
|---|---|---|---|---|---|---|
| | | | | Central | Lower | Upper |
| **Triclopyr Acid Runoff Rates[2] (at right)** | | | | 0.45% | 0.04% | 1.61% |
| **Maximum Treatment Scenario[3]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 38.7 | 154.6 | 43 | 0.0002 | 2E-05 | 0.0007 |
| East Side watersheds (Southeast WWTP)[4] | 9.3 | 37.4 | 110 | 2E-05 | 2E-06 | 7E-05 |
| **Half-Treatment Scenario[5]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 19.3 | 77.3 | 43 | 0.0001 | 9E-06 | 0.0003 |
| East Side watersheds (Southeast WWTP)[4] | 4.7 | 18.7 | 110 | 9E-06 | 8E-07 | 3E-05 |
| **Quarter-Treatment Scenario[6]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 9.7 | 38.7 | 43 | 5E-05 | 4E-06 | 0.0002 |
| East Side watersheds (Southeast WWTP)[4] | 2.3 | 9.3 | 110 | 5E-06 | 4E-07 | 2E-05 |
| **Demonstration Projects 1 and 4[7]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 1 | 4 | 43 | 5E-06 | 4E-07 | 2E-05 |
| East Side watersheds (Southeast WWTP)[4] | 2 | 8 | 110 | 4E-06 | 3E-07 | 1E-05 |

MGD = million gallons per day; WWTP = wastewater treatment plant.

[1] Acres treated and maximum pounds applied are per year were determined by the application guidelines and the treatment schedule. Pounds applied are given as acid equivalents, a.e. See Section 2.5.1.B for complete details.

[2] Triclopyr acid runoff rate is calculated as a percent of applied triclopyr BEE that runs off of a treated area and degrades to triclopyr acid. Estimates are based on USFS GLEAMS modeling and are taken from Appendix 10, Table A10-1 in the USFS risk assessment.

[3] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[4] West side watersheds, which flow to Oceanside WWTP, are those numbered 1, 6, and 8–13 in Appendix B; East side watersheds, which flow to Southeast WWTP, are those numbered 2–5 and 7 in Appendix B.

[5] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[6] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[7] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

**Table 4-17: TCP Concentrations at Wastewater Treatment Plants During the 5-Year Storm**

| Scenario | Acres Treated per Year at 4 lb/acre[1] | Max Lbs Triclopyr a.e. Applied Per Year[1] | WWTP In-plant Capacity (MGD) | TCP Concentration (mg/L) | | |
|---|---|---|---|---|---|---|
| | | | | Central | Lower | Upper |
| **TCP Runoff Rates[2] (at right)** | | | | 0.043% | 0.0124% | 0.27% |
| **Maximum Treatment Scenario[3]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 38.7 | 154.6 | 43 | 2E-05 | 5E-06 | 0.0001 |
| East Side watersheds (Southeast WWTP)[4] | 9.3 | 37.4 | 110 | 2E-06 | 5E-07 | 1E-05 |
| **Half-Treatment Scenario[5]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 19.3 | 77.3 | 43 | 9E-06 | 3E-06 | 6E-05 |
| East Side watersheds (Southeast WWTP)[4] | 4.7 | 18.7 | 110 | 9E-07 | 3E-07 | 6E-06 |
| **Quarter-Treatment Scenario[6]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 9.7 | 38.7 | 43 | 5E-06 | 1E-06 | 3E-05 |
| East Side watersheds (Southeast WWTP)[4] | 2.3 | 9.3 | 110 | 4E-07 | 1E-07 | 3E-06 |
| **Demonstration Projects 1 and 4[7]** | | | | | | |
| West Side watersheds (Oceanside WWTP)[4] | 1 | 4 | 43 | 5E-07 | 1E-07 | 3E-06 |
| East Side watersheds (Southeast WWTP)[4] | 2 | 8 | 110 | 4E-07 | 1E-07 | 2E-06 |

MGD = million gallons per day; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr; WWTP = wastewater treatment plant.

[1] Acres treated and maximum pounds applied are per year were determined by the application guidelines and the treatment schedule. Pounds applied are given as acid equivalents, a.e. See Section 2.5.1.B for complete details.

[2] TCP runoff rate is calculated as a percent of applied triclopyr BEE that runs off of a treated area and degrades to TCP. Estimates are based on USFS GLEAMS modeling and are taken from Appendix 11, Table A11-1 in the USFS risk assessment.

[3] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[4] West side watersheds, which flow to Oceanside WWTP, are those numbered 1, 6, and 8–13 in Appendix B; East side watersheds, which flow to Southeast WWTP, are those numbered 2–5 and 7 in Appendix B.

[5] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.

[6] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.

[7] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

### 4.5.4 Risks to Humans

Human exposure estimates were performed for both workers and members of the general public. For herbicide applicators ("workers"), accidental/incidental and general handling exposures were considered for cut-stump applications. General public exposure estimates were developed for the scenarios of people sitting on treated stumps, direct sprays, a woman or child drinking contaminated water, and herbicide runoff to private property. Acute and chronic exposure scenarios were evaluated to obtain a range of exposure estimates for worst-case ("Upper"), more probable ("Central") and best-case ("Lower") exposure scenarios.

For women of childbearing age, hazard quotients for triclopyr BEE or triclopyr acid acute exposures are approximately 20 times those for men and children because the acute RfD for women is 0.05 mg/kg per day, compared to 1.0 mg/kg per day for men and children, for triclopyr BEE. This difference in RfD is due to the risk of birth defects if pregnant women come in contact with triclopyr BEE or its degradation product triclopyr acid. For TCP, there is no difference in RfD by gender. For chronic exposures, the RfD for triclopyr BEE and triclopyr acid is 0.05 mg/kg per day for both women and men. Doses per kilogram of body weight differ between female and male workers by approximately 10 percent due to a lower weight assumed for females (64 kg) compared to males (70 kg).

#### *4.5.4.A Workers*

Risks from accidental exposure and general handling exposure scenarios were calculated for workers. Accidental exposures include wearing contaminated gloves for one minute or one hour, a spill onto hands, and a spill onto lower legs. General handling exposures are per-day doses calculated as a function of the pounds per acre of herbicide applied, hours worked per day and acres treated per hour using cut-stump techniques. Sitting on a treated stump was not modeled for workers as it was for the general public, because it is considered unlikely that workers, who are at work and are aware of the meaning of the dye visible on treated stumps, would sit on a treated stump. Confidence in these exposure assessments is reasonably high because of the availability of dermal absorption data in humans as well as worker exposure studies. Doses and hazard quotients for all worker exposure scenarios can be found in Table 4-18 and Figure 4-6 below.

Dermal exposure is of particular concern for triclopyr, so special application guidelines have been added for workers applying this herbicide. Specifically, precautions should be taken to avoid spills to unprotected skin and eyes, including the use of goggles, double gloves, long-sleeved clothing and closed shoes. Applicators should have extra gloves, soap and water for washing off spills, and an eyewash bottle in their vehicle at all times.

Because of the high dermal permeability of triclopyr BEE, workers were found to be at risk of receiving doses in excess of the RfD for adult males and adult females, even for the most probable Central exposure estimates for spills and for Upper estimates of general exposure. Workers are most at risk from wearing contaminated gloves that trap the herbicide solution next to the skin for one hour. All estimates for this scenario exceed RfDs for male and female workers; even best-case Lower estimates exceed RfDs by a factor of 82 for female workers and a factor of 3.7 for male workers. This scenario is considered **Improbable** and is independent of application rate, since exposure is calculated on a per-event basis.

The Central dose estimates for three of the four accidental exposure scenarios exceed the RfD for female workers. Spills are particularly problematic for female workers; even best-case Lower exposure estimates exceed 10 percent of the RfD for adult females, and Upper exposure estimates are 1.6 and 3.5 times the RfD for spills to hands and legs, respectively.
Only a spill on hands left unwashed for one hour results in a Central estimated dose below the RfD, but this exposure is approaching a level of concern at 62 percent of the RfD for females.

The risk characterizations suggest that workers would also be at risk of exceeding the RfD due to general handling of Garlon 4A Ultra. The cut-stump general handling exposure scenario is considered **Highly Probable** because it represents exposure as a result of typical working environments using standard personal protective equipment. (Upper and Lower exposure estimates are inherently less likely than Central estimates because they model extreme values for every parameter.) General handling exposures are very close to the level of concern for female workers even using best-case Lower exposure estimates. For male workers, estimates approach the level of concern given Central estimates, but are only above levels of concern using worst-case Upper assumptions. For general handling exposure, the Upper estimate assumes maximum hours worked per day (8 hours), maximum acres treated per hour (0.2 acre per hour) and maximum dermal absorption. Precautions should be taken to avoid spills to unprotected skin and eyes, including the use of goggles, gloves, long-sleeved clothing and closed shoes. Applicators should have extra gloves, soap and water for washing off spills, and an eyewash bottle in their vehicle at all times.

**Most Likely Exposures:** Exposure estimates from the scenarios that are the most likely to occur for workers are highlighted below:

1. **General handling exposure due to backpack spraying (Highly Probable** for Demonstration Projects and Main Project).
   Central exposure estimates are estimated to be 99 percent of the acute/chronic RfD for adult females and 91 percent of the chronic RfD for males for applications at 4 lb/acre. The Upper estimate is 3.8 times the RfD for female workers and 17 percent of the RfD for male workers. Reducing the application rate decreases the exposure proportionately, but application of one pound per acre still result in Central exposures approaching the level of concern for women and men at 25 and 23 percent of the chronic RfD, respectively.
2. **Wearing contaminated gloves for one minute (Probable** for Demonstration Projects and Main Project**).**
   The Central dose estimate for wearing gloves contaminated with herbicide at cut-stump concentrations for one minute is 5.5 times the RfD for female workers and 25 percent of the RfD for male workers. The Upper estimate is 14 times the RfD for female workers and 62 percent of the RfD for male workers. This scenario is independent of application rate, since exposure is calculated on a per-event basis.

**Highest Exposures:** It is also useful to consider the scenarios that yield the highest exposures, regardless of their probability, to evaluate the potential need for additional precautions that might be needed to protect the public. A number of Central exposure scenarios result in HQs above 1 for triclopyr:

1. **Wearing contaminated gloves left unwashed for one hour (Improbable).**
   This is the highest calculated dermal worker exposure, with even the best-case Lower dose estimates 82 times the RfD for female workers and 3.7 times the RfD for male workers. The

Central dose estimate for wearing gloves contaminated with concentrated product for one hour is 327 and 15 times the RfD for female and male workers respectively. The Upper estimate is 818 and 37 times the RfD for female and male workers respectively. This scenario is independent of application rate, since exposure is calculated on a per-event basis.

2. **Accidental spill to the lower legs left unwashed for one hour (Improbable).** A spill of diluted product to the lower legs that is left unwashed for one hour results in estimated doses 1.4 times (Central) and 3.5 times (Upper) the RfD for female workers. For male workers, only the Upper estimate is below the level of concern at16 percent of the RfD. This scenario is independent of application rate, since exposure is calculated on a per-event basis.
3. **Accidental spill on the hands left unwashed for one hour (Improbable).** The Central exposure estimate for spill to the hands for female workers is 62 percent of the RfD, with only the Upper estimate exceeding the RfD by 1.6 times. For male workers, all doses are below levels of concern. This scenario is independent of application rate, since exposure is calculated on a per-event basis.

We recommend that for all workers with the potential for exposure to triclopyr and triclopyr-treated vegetation, UCSF require training regarding the specific risks associated with exposure in excess of that required by OSHA and Cal-DPR standards.

If accidental worker exposures occur, the dose from that scenario can be added to the general exposure to obtain an aggregate dose. For example, if a worker treats cut stumps for eight hours and also wears a contaminated glove for one hour, the combined Upper exposure estimate for triclopyr BEE is 0.19 + 41 = 41.19 mg/kg-day. In this case, the spill exposure estimates are much higher than the general exposure for triclopyr, thus general exposure does not contribute significantly to the aggregate exposure. However, multiple spills and continued wearing of contaminated gloves would quickly add up to very high aggregate exposures and should be avoided.

A contributing factor to the high male worker risks calculated for triclopyr is the assumption that applicators may apply triclopyr regularly over one to six months. This is a chronic exposure scenario with an RfD of 0.05 mg/kg, a factor of 20 lower than the acute RfD of 1.0 mg/kg. For women applicators, the RfD of 0.05 applies to all scenarios, both acute and chronic, because of risks of birth defects to the fetus if the woman is pregnant.

These exposure estimates do not include splashes into the eyes, as there are no quantitative, systemic exposure estimates for this scenario. Garlon 4 Ultra is slightly irritating to the eyes,[146] but little systemic absorption would be expected from such an event.

Confidence in these exposure assessments is reasonably high because of the availability of dermal absorption data in humans as well as worker exposure studies. All estimates assume workers wear standard personal protective equipment.

We conclude that the most significant risk to workers is from dermal exposure due to accidental spills. The risk is significantly greater for women of childbearing age. Precautions should be taken to avoid spills to unprotected skin and eyes, including the use of goggles, double gloves, long-sleeved clothing and closed shoes. Applicators should have extra clean gloves readily available, soap and water for washing off spills, and an eyewash bottle in their vehicle at all

times. Rubber boots are highly recommended. If triclopyr is to be used, applicators must be adequately trained in avoiding direct contact with the chemical.

### Table 4-18: Estimated Risks for Workers from Triclopyr BEE Exposures

| Scenario | Duration | Dose Central | Dose Lower | Dose Upper | RfD (mg/kg-day) | Hazard Quotients Central | Hazard Quotients Lower | Hazard Quotients Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Accidental Exposures (mg/kg body weight/event) at Cut-stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| **Female Worker** | | | | | | | | | |
| Contaminated Gloves | 1 min | 0.27 | 0.068 | 0.68 | 0.05 | **5.5** | **1.4** | **14** | **Pr / Pr** |
| | 1 hr | 16 | 4.1 | 41 | 0.05 | **327** | **82** | **818** | I / I |
| Spill on hands | 1 hr | 0.031 | 0.0078 | 0.078 | 0.05 | 0.62 | 0.16 | **1.6** | I / I |
| Spill on lower legs | 1 hr | 0.070 | 0.018 | 0.18 | 0.05 | **1.4** | 0.35 | **3.5** | I / I |
| **Male Worker** | | | | | | | | | |
| Contaminated Gloves | 1 min | 0.25 | 0.062 | 0.62 | 1 | 0.25 | 0.062 | 0.62 | **Pr / Pr** |
| | 1 hr | 15 | 3.7 | 37 | 1 | **15** | **3.7** | **37** | I / I |
| Spill on hands | 1 hr | 0.028 | 0.0071 | 0.071 | 1 | 0.028 | 0.0071 | 0.071 | I / I |
| Spill on lower legs | 1 hr | 0.064 | 0.016 | 0.16 | 1 | 0.064 | 0.016 | 0.16 | I / I |
| **General Handling Exposure (mg/kg body weight/day) for Cut-stump Worker (at 0.1-0.2 acre/hr) based on 6-8 hrs worked** | | | | | | | | | |
| **Four pounds per acre applied** | | | | | | | | | |
| Female Worker | 6-8 hrs | 0.050 | 0.0071 | 0.19 | 0.05 | 0.99 | 0.14 | **3.8** | **HP / HP** |
| Male Worker | 6-8 hrs | 0.045 | 0.0065 | 0.17 | 0.05 | 0.91 | 0.13 | **3.5** | **HP / HP** |
| **Two pounds per acre applied** | | | | | | | | | |
| Female Worker | 6-8 hrs | 0.025 | 0.004 | 0.095 | 0.05 | 0.50 | 0.071 | **1.9** | **HP / HP** |
| Male Worker | 6-8 hrs | 0.023 | 0.0032 | 0.09 | 0.05 | 0.45 | 0.065 | **1.7** | **HP / HP** |
| **One pound per acre applied** | | | | | | | | | |
| Female Worker | 6-8 hrs | 0.012 | 0.002 | 0.047 | 0.05 | 0.25 | 0.035 | 0.95 | **HP / HP** |
| Male Worker | 6-8 hrs | 0.011 | 0.0016 | 0.04 | 0.05 | 0.23 | 0.032 | 0.87 | **HP / HP** |

RfD = Reference dose. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

Hazard Quotients greater than 0.1 are shaded. Hazard Quotients greater than one are also **bolded.**

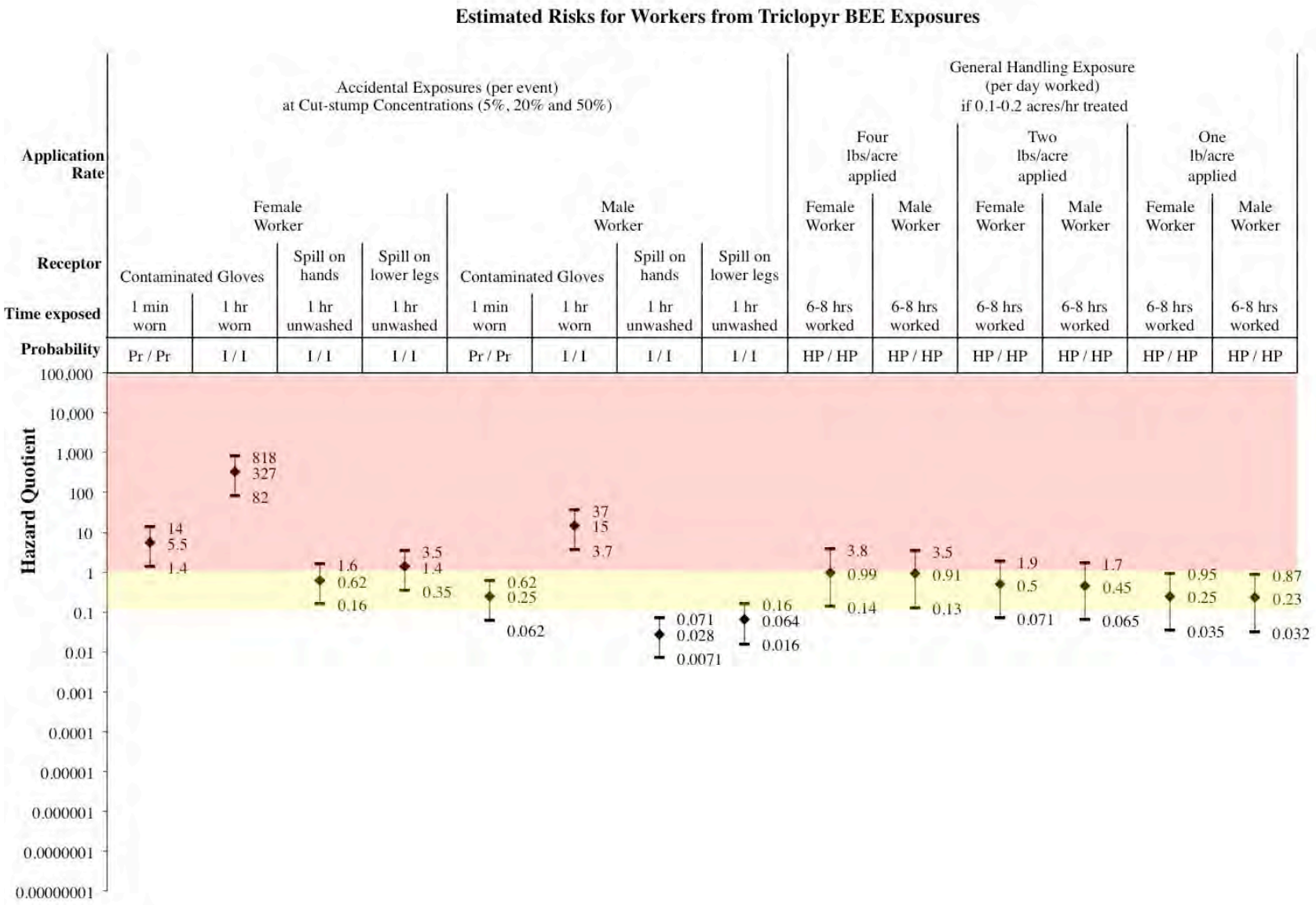



**Figure 4-6**: Estimated risks of triclopyr BEE exposures for workers. See Table 4-18 above for data used to create this chart and definitions of terminology and abbreviations used.

#### *4.5.4.B General Public*

Acute and chronic triclopyr exposure scenarios for the general public were evaluated for direct spray of a child or adult female, contact with treated stumps, a woman or child drinking contaminated water, and herbicide runoff to private property. Contact with or consumption of contaminated fruit and vegetation were not considered because no foliar application of triclopyr is proposed for Mount Sutro. The risks associated with dermal exposure scenarios for the general public are summarized in Table 4-19 and Figure 4-7.

Consumption of contaminated water is evaluated for a child drinking from a small puddle or pool and for a child or woman drinking from a pool in Woodland Creek after a spill or during peak or long-term runoff under the different treatment scenarios (Maximum, Half, Quarter and Demonstration Project). The risks associated with contaminated water exposure scenarios for the general public are summarized in Table 4-20 and Figure 4-8. In order to focus on the highest exposures, an adult male was not evaluated because the corresponding doses would be lower per kilogram of body weight, given the higher weight assumed for an adult male. Contamination of drinking water reservoirs from runoff of triclopyr in the watershed is not considered because no reservoirs are so located as to potentially intercept herbicide runoff from Mount Sutro; Laguna Honda Reservoir to the southwest of Mount Sutro is separated from the project area by city streets which will route runoff to city stormwater systems. (Runoff to wastewater treatment plants is considered in Section 4.5.3 above.)

For homes that border the reserve, the probability of herbicide-contaminated runoff entering private property is very low and does not exceed levels of concern for the highly improbable scenario of humans drinking contaminated water from runoff.

**Most Likely Exposures:** Table 2-10 in Chapter 2 summarizes the probabilities assumed for each scenario. Only one triclopyr exposure scenario is considered to be **Possible** for the general public (though **Improbable** for Demonstration Projects). This scenario—sitting on a treated stump for one hour while wearing shorts—is evaluated for two possible receptors:

1. **A woman wearing shorts sitting on a treated stump for one hour** (**Possible** for Main Project; **Improbable** for Demonstration projects).
   The Central dose estimates for a woman sitting on a treated stump for one hour is 12 percent of the acute RfD for adult females, with the Upper estimate at 96 percent of the RfD, indicating that this scenario approaches a level of concern.
2. **A child wearing shorts sitting on a treated stump for one hour** (**Possible** for Main Project; **Improbable** for Demonstration projects).
   A child exposed in this way would receive a dose below ten percent of the RfD due to the higher triclopyr RfD for children than adult females. The Central dose estimates for a child sitting on a treated stump for one hour is one percent of the acute RfD for adult females, and the Upper estimate is 8.2 percent of the RfD, neither of which approaches the level of concern.

**Highest Exposures:** It is also useful to consider the scenarios that yield the highest exposures, regardless of their probability, to evaluate the potential need for additional precautions that might

be needed to protect the public. For triclopyr, the following scenarios exceeded an HQ of one for Lower, Central, and Upper estimates::

1. **A child drinking from a puddle or pool or Woodland Creek contaminated by a one-gallon spill (Highly Improbable** for Main Project or Demonstration Projects**)**.
   All of these scenarios would lead to exposures at least 2.4 times and up to more than 20,000 times the RfD, depending on the size of spill and concentration of herbicide spilled. Central estimated doses are 32 times the RfD for a one-gallon spill and 642 times the RfD for a 20 gallon spill into larger pools formed in Woodland Creek.
2. **Direct spray of an adult female over her feet and lower legs (Highly Improbable)**
   The Central estimate is above the level of concern at 2.2 times the RfD for an adult female, which assumes a 20-percent solution is sprayed. The Lower estimate, which assumes a five-percent solution, is 54 percent of the RfD.

If the Application Guidelines (Section 2.5.1) are adhered to, a one-gallon spill is considered **Improbable** and drinking contaminated water is considered **Highly Improbable** because pools and puddles and Woodland Creek are not normally used as drinking water sources.

Exposure from brushing against contaminated vegetation is not evaluated for triclopyr because triclopyr is only being considered for use in cut-stump treatments. Eating contaminated berries is not considered because the only berries on Mount Sutro commonly eaten by humans, blackberries, will be cut prior to herbicide treatment, according to the Application Guidelines.

**Water Consumption Scenarios:** Although contamination by peak or long-term herbicide runoff is considered **Probable** due to the likelihood of rain within or soon after the window of application, it is considered **Highly Improbable** that the general public would drink regularly, if at all, from Woodland Creek. Concentrations of triclopyr BEE, triclopyr acid or TCP in Woodland Creek due to runoff are estimated to be low enough that even worst-case (Upper) dose estimates of drinking scenarios are relatively low: Eighteen percent of the RfD for an adult female drinking water contaminated with triclopyr acid (long-term runoff) or 11 percent of the RfD for a child (peak runoff). Upper dose estimates assume all acres within the Woodland Creek watershed are treated at four pounds per acre of triclopyr. No Central estimates of humans drinking contaminated runoff approach the level of concern. Treatment of fewer acres each year would reduce HQs further.

### Table 4-19: Estimated Risks for the General Public from Triclopyr BEE Accidental Acute Dermal Exposures

| Scenario | Receptor | Dose (mg/kg per event) Central | Lower | Upper | RfD (mg/kg-day) | Hazard Quotients Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Direct Spray of Cut-Stump Treatment Solution (5%, 20% or 50%)** | | | | | | | | | |
| Whole body | Child | 1.1 | 0.27 | 2.7 | 1 | **1.1** | 0.27 | **2.7** | HI / HI |
| Feet and lower legs | Adult Female | 0.11 | 0.027 | 0.27 | 0.05 | **2.2** | 0.54 | **5.4** | HI / HI |
| **Treated-Stump Contact, One Hour, Sitting, Shorts** | | | | | | | | | |
| | Child | 0.010 | 0.0019 | 0.082 | 1 | 0.010 | 0.0019 | 0.082 | I / **Po** |
| | Adult Female | 0.0059 | 0.0011 | 0.048 | 0.05 | 0.12 | 0.022 | 0.96 | I / **Po** |

RfD = Reference Dose. ; Triclopyr BEE = triclopyr butoxyethyl ester; DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable.
Hazard Quotients greater than 0.1 are shaded. Hazard Quotients greater than one are also **bolded.**

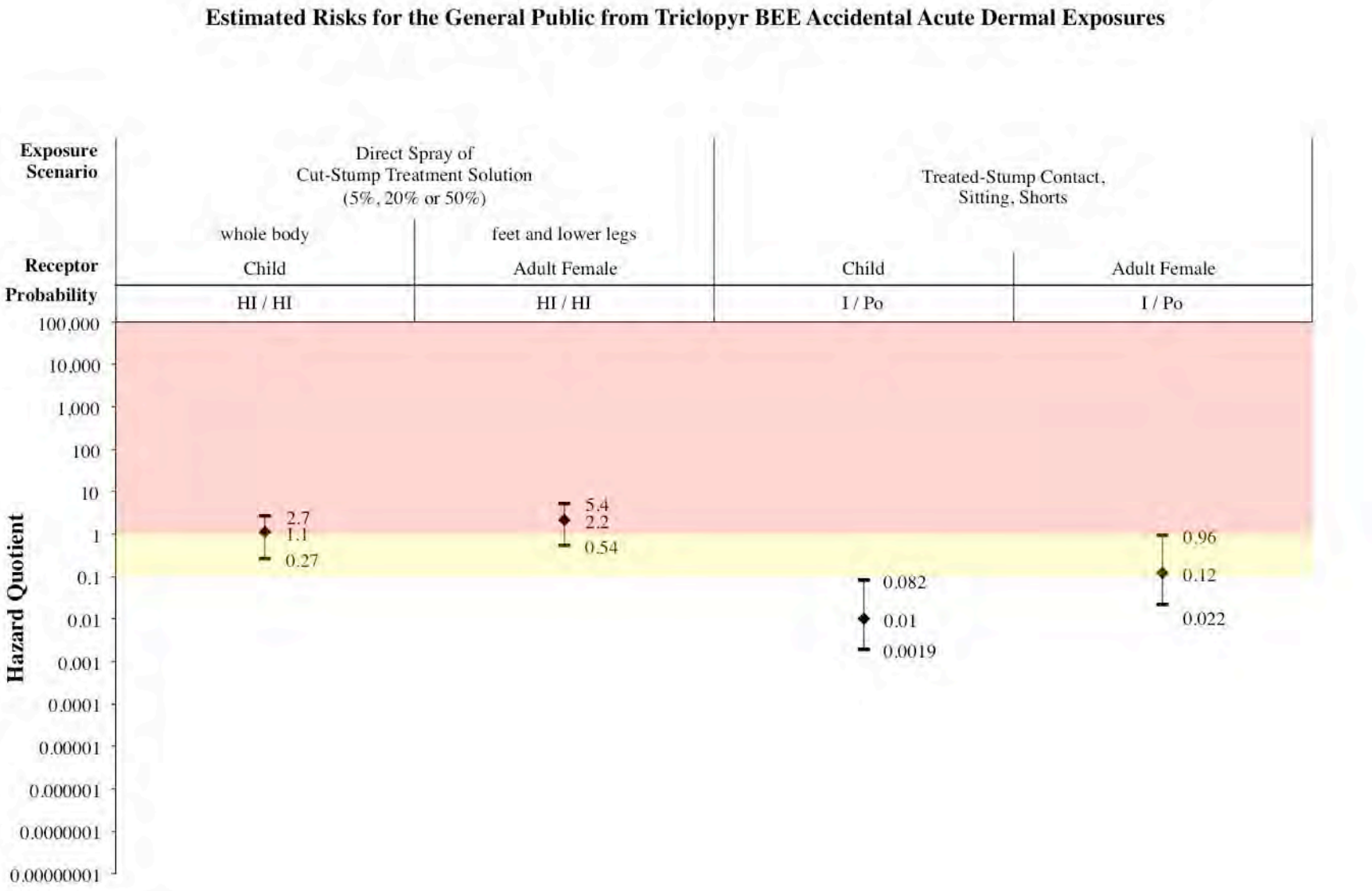



**Figure 4-7**: Estimated risk of triclopyr BEE acute dermal exposures for the general public. See Table 4-19 above for data used to create this chart and definitions of terminology and abbreviations used.

## Table 4-20: Estimated Risks for Humans Drinking Triclopyr-Contaminated Water

| Scenario | Form of Triclopyr[1] | Receptor | Dose (mg/kg body weight/event) Central | Lower | Upper | RfD (mg/kg-day) | Hazard Quotients Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spill to a Puddle/Pool (5-100 L volume) of One Gallon of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | | |
| 1 gallon | BEE | Child | 545 | 42 | 20,456 | 1 | **545** | **42** | **20,456** | HI / HI |
| **Spill to a Woodland Creek pool (340-1,700 L volume) of 1-20 Gallons of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | | |
| 1 gallon | BEE | Child | 32 | 2.4 | 301 | 1 | **32** | **2.4** | **301** | HI / HI |
| 20 gallons | BEE | Child | 642 | 49 | 6,016 | 1 | **642** | **49** | **6,016** | HI / HI |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | | |
| Peak runoff[3] | BEE | Child | 0.0001 | 3E-08 | 0.014 | 1 | 0.0001 | 3E-08 | 0.014 | HI / HI |
| | Acid | Child | 0.0090 | 2E-07 | 0.11 | 1 | 0.0090 | 2E-07 | 0.11 | HI / HI |
| | TCP | Child | 0.0003 | 2E-09 | 0.013 | 1 | 0.0003 | 2E-09 | 0.013 | HI / HI |
| Long-term runoff[3] | Acid | Adult Female | 4E-05 | 7E-13 | 0.0090 | 0.05 | 0.0008 | 1E-11 | 0.18 | HI / HI |
| | TCP | Adult Female | 2E-06 | 1E-14 | 0.0003 | 0.05 | 4E-05 | 2E-13 | 0.0060 | HI / HI |
| **Half Treatment Scenario[4]** | | | | | | | | | | |
| Peak runoff[3] | BEE | Child | 6E-05 | 1E-08 | 0.0068 | 1 | 6E-05 | 1E-08 | 0.0068 | HI / HI |
| | Acid | Child | 0.0045 | 9E-08 | 0.054 | 1 | 0.0045 | 9E-08 | 0.054 | HI / HI |
| | TCP | Child | 0.0001 | 9E-10 | 0.0063 | 1 | 0.0001 | 9E-10 | 0.0063 | HI / HI |
| Long-term runoff[3] | Acid | Adult Female | 2E-05 | 4E-13 | 0.0045 | 0.05 | 0.0004 | 7E-12 | 0.090 | HI / HI |
| | TCP | Adult Female | 1E-06 | 5E-15 | 0.0002 | 0.05 | 2E-05 | 1E-13 | 0.0030 | HI / HI |
| **Quarter Treatment Scenario[5]** | | | | | | | | | | |
| Peak runoff[3] | BEE | Child | 3E-05 | 7E-09 | 0.0034 | 1 | 3E-05 | 7E-09 | 0.0034 | HI / HI |
| | Acid | Child | 0.0023 | 5E-08 | 0.027 | 1 | 0.0023 | 5E-08 | 0.027 | HI / HI |
| | TCP | Child | 7E-05 | 5E-10 | 0.0032 | 1 | 7E-05 | 5E-10 | 0.0032 | HI / HI |
| Long-term runoff[3] | Acid | Adult Female | 1E-05 | 2E-13 | 0.0023 | 0.05 | 0.0002 | 4E-12 | 0.045 | HI / HI |
| | TCP | Adult Female | 5E-07 | 3E-15 | 8E-05 | 0.05 | 1E-05 | 5E-14 | 0.0015 | HI / HI |
| **Demonstration Plot #4[6]** | | | | | | | | | | |
| Peak runoff[3] | BEE | Child | 3E-05 | 8E-09 | 0.0038 | 1 | 3E-05 | 8E-09 | 0.0038 | HI / HI |
| | Acid | Child | 0.0025 | 5E-08 | 0.031 | 1 | 0.0025 | 5E-08 | 0.031 | HI / HI |
| | TCP | Child | 8E-05 | 5E-10 | 0.0036 | 1 | 8E-05 | 5E-10 | 0.0036 | HI / HI |
| Long-term runoff[3] | Acid | Adult Female | 1E-05 | 2E-13 | 0.0025 | 0.05 | 0.0002 | 4E-12 | 0.051 | HI / HI |
| | TCP | Adult Female | 6E-07 | 3E-15 | 8E-05 | 0.05 | 1E-05 | 6E-14 | 0.0017 | HI / HI |

RfD = Reference Dose; WWTP = Waste water treatment plant; BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid. Hazard Quotients above 0.1 are shaded. HQs greater than one are **bolded.**

DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.

[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.

[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

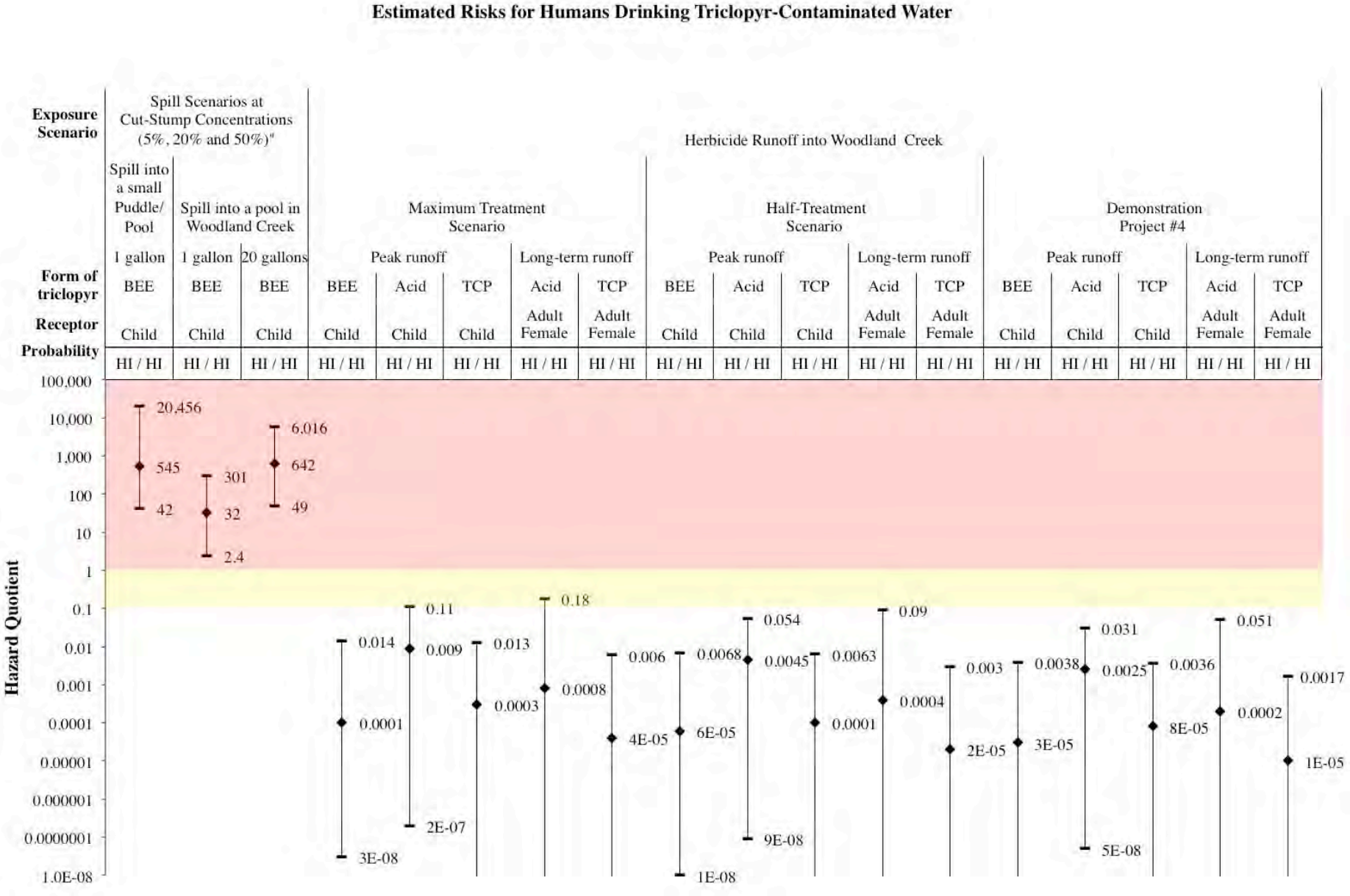



**Figure 4-8**: Estimated risks for humans drinking triclopyr-contaminated water. See Table 4-20 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$.

### 4.5.5 Risks to Wildlife

The wildlife risk assessment is divided into two parts, terrestrial and aquatic. For terrestrial animals, risks are assessed for dermal, food and drinking water exposures resulting from spills, peak runoff, and long-term runoff to Woodland Creek under Maximum, Half, Quarter and Demonstration plot scenarios. For aquatic wildlife, risks are assessed for spills and peak runoff and long-term runoff to Woodland Creek under Maximum, Half, Quarter and Demonstration plot scenarios, as well as short-term runoff to the Southeast and Oceanside WWTPs. See Section 2.5 for a discussion of the methods used to estimate wildlife exposures. Acute and chronic exposure scenarios were evaluated to obtain a range of exposure estimates for worst-case ("Upper"), more probable ("Central") and best-case ("Lower") exposure scenarios.

Aquatic wildlife are at much greater risk from triclopyr exposure compared to terrestrial wildlife. Several terrestrial scenarios produced HQs greater than one for a single exposure. The only aquatic scenarios considered **Possible** or **Probable** are the long-term runoff scenarios. Exposures from these scenarios exceeded TRVs for Upper estimates of triclopyr exposure for amphibians, aquatic invertebrates and aquatic plants living on Mount Sutro.

For homes that border the reserve, the probability of triclopyr-contaminated runoff entering private property is very low and does not exceed levels of concern for the probable scenarios of terrestrial wildlife or household pets drinking contaminated water from runoff, or for amphibians or plants on private property.

#### *4.5.5.A Terrestrial Wildlife*

The wildlife scenarios developed in the SERA worksheets are generally representative of the Mount Sutro settings. Table 4-21 and the accompanying Figure 4-9 shows the acute and chronic risk estimates for dermal and food exposures for mammals and birds. Tables 4-22 through 4-25 and Figures 4-10 through 4-13 show risk estimates for drinking contaminated water for mammals and birds, respectively. See Section 2.5.4 for a discussion of the methods used to estimate wildlife exposures and Section 4.3.2 on page 4-30 for a summary of triclopyr toxicity studies on terrestrial organisms and a discussion of the choice of specific TRVs used for wildlife exposure to triclopyr. Unlike human RfDs, wildlife TRVs do not include uncertainty factors; however, TRVs for sensitive species were selected for this risk assessment, which will ensure most species are protected.

In general, terrestrial wildlife scenarios of concern are consumption by a small mammal or small bird of water contaminated by a spill, direct spray of a small mammal, and ingestion of contaminated insects by a small bird. Using most likely (Central) assumptions, these scenarios approach the level of concern for all species evaluated; using worst-case (Upper) assumptions, these scenarios all exceed the level of concern. None of the estimates for the scenarios that involve drinking contaminated runoff exceed two percent of the TRV for any terrestrial wildlife evaluated.

Consumption of water contaminated by 1–20 gallons of triclopyr leads to the highest exposure estimates for terrestrial wildlife, which approach or exceed levels of concern (HQ=1) for all species evaluated when using Central assumptions of the amount ingested and the weight of the individual animals.

**Most Likely Exposures:** Below are the potential terrestrial wildlife exposures considered **Probable** or **Possible** for the Main Project; probabilities for Demonstration Projects are usually lower (as discussed in Table 2-13). Data are summarized for **Probable** and **Possible** exposures below, which are variations of acute consumption of contaminated fruit or insects by a small mammal or bird and consumption of a contaminated small mammal by a carnivorous mammal or bird. Lower, Upper and Central estimates assume 10, 30 or 100 percent respectively of the receptor's diet is contaminated.

1. **A small bird eating contaminated insects (Possible** for the Main Project; **Improbable** for Demonstration Projects**)**.
   This scenario has the highest worst-case (Upper) estimated risk among Probable or Possible exposures to terrestrial wildlife. The Central dose is estimated at 36 percent of the TRV, with an Upper estimate at 3.6 times the TRV.
2. **Direct spray of 50 percent of a small mammal's body, assuming first order absorption (Possible** for the Main Project; **Improbable** for Demonstration Projects**)**
   The highest Central exposure estimate among Probable or Possible exposures to terrestrial wildlife is this direct spray scenario. The Central estimate assumes a small mammal is sprayed by a 20 percent solution of triclopyr BEE and results in a dose that approaches the level of concern at 79 percent of the TRV for a small mammal. The Upper estimate, which assumes a 50 percent solution sprayed, is 7.8 times the TRV.
3. **Consumption of contaminated insects by a small mammal (Possible** for the Main Project; **Improbable** for Demonstration Projects**).**
   The Central estimate for a small mammal eating contaminated insects as 30 percent of the diet is 6.3 percent of the TRV. The worst-case (Upper) dose estimate is 63 percent of the TRV.
4. **Consumption of contaminated prey (a small mammal) by carnivorous mammals or birds (Possible** for the Main Project; **Improbable** for Demonstration Projects**).**
   Central estimates of exposures for carnivorous mammals and birds are less than 10 percent of their respective TRVs—3.1 percent of the TRV for carnivorous birds and 0.57 percent for carnivorous mammals. The Upper estimates are 10 percent and 1.9 percent of the TRVs for a carnivorous bird or mammal, respectively.
5. **Chronic consumption of contaminated fruit by a small mammal, on-site (Possible** for the Main Project; **Improbable** for Demonstration Projects**).**
   This chronic scenario was evaluated for triclopyr acid and TCP, since triclopyr BEE degrades rapidly. The most likely (Central) estimate for triclopyr acid is just 2.5 percent of the chronic TRV for small mammals; the Central estimate for TCP is 4.6 percent of the TRV. Upper estimates for triclopyr acid and TCP do approach levels of concern, at 31 percent and 57 percent of the TRV, respectively. On-site chronic exposures are higher than off-site exposures, and the latter are considered **Highly Improbable**.
6. **Drinking water from Woodland Creek contaminated by peak or long-term runoff (Probable** for the Main Project and Demonstration Projects**).**
   None of the estimates for scenarios involving drinking contaminated runoff exceed two percent of the TRV for any terrestrial wildlife evaluated.

**Highest Exposures:** It is also useful to consider the scenarios that yield the highest exposures, regardless of their probability, to evaluate the potential need for additional precautions that might be needed to protect wildlife. For terrestrial wildlife, the following scenarios led to the highest exposure estimates:

1. **Drinking water from a Woodland Creek pool contaminated by a 20-gallon spill (Improbable** for Main Project or Demonstration Project 4; N/A for Demonstration Project 1, which does not drain to Woodland Creek)
   The highest exposure estimates for terrestrial wildlife involve drinking contaminated water after a spill of ten gallons of 20 percent Garlon 4 Ultra (Central estimate) or 20 gallons of 50 percent Garlon 4 Ultra (Upper estimate) into Woodland Creek diluted into a volume of water between 340 and 1,700 Liters. The highest exposure estimate is for a carnivorous mammal, which would ingest a dose 180 times the acute TRV for the Central estimate. While the carnivorous mammal risk is highest, dose estimates for the equivalent scenario involving a small mammal are also above the level of concern.
2. **Drinking from a puddle or pool contaminated by a one-gallon spill (Improbable** for the Main Project or the Demonstration Projects**)**.
   This scenario produced Central estimates of at least 2.2 times the triclopyr BEE TRV (for large birds) to 31 times the TRV (for carnivorous mammals), assuming a 20 percent solution of Garlon 4 Ultra is spilled into a 20-liter puddle. Differences between species evaluated are due to assumptions about the weight of the animal and amount ingested. Even best-case (Lower) estimates exceed levels of concern only for carnivorous mammals and small birds at 3.8 and 1.9 times the respective TRVs. Lower estimates approach levels of concern for small mammals and large birds.
3. **Direct spray of a small mammal, assuming 100 percent absorption (Improbable** for the Main Project and **Highly Improbable** for the Demonstration Projects**)**.
   In the most likely (Central) and Upper estimates, this scenario is problematic for small mammals, which may not be visible to applicators. Central HQs are 11 times the acute TRV for small mammals exposed to triclopyr BEE; Upper estimates are 110 times the TRV. However, this scenario assumes that 100 percent of the chemical on wildlife skin or fur is ingested through grooming, so it is considered **Improbable**.

Table 4-21 summarizes the acute and chronic exposure estimates and hazard quotients for terrestrial wildlife exposure scenarios. Unlike human RfDs, wildlife TRVs do not include uncertainty factors. If uncertainty factors were applied to the TRVs, hazard quotients would more frequently exceed one.

**Table 4-21: Estimated Risks for Terrestrial Wildlife Exposed to Triclopyr BEE through Direct Sprays and Food Consumption**

| Scenario | Form of Triclopyr[1] | Receptor | Dose (mg/kg body weight/event) Central | Lower | Upper | TRV (mg/kg-day) | Hazard Quotients Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Direct Spray of 50% of Receptor's Body Surface with Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | | |
| First-order absorption | BEE | Small mammal | 348 | 2.8 | 3,427 | 440 | 0.79 | 0.006 | **7.8** | I / **Po** |
| 100% absorption | BEE | Small mammal | 4,849 | 48 | 48,488 | 440 | **11** | 0.11 | **110** | HI / I |
| **Acute Consumption of Contaminated Fruit, Insects or Smalls Mammals as 10%, 30% or 100% of Diet by Receptor** | | | | | | | | | | |
| Consumption of Contaminated Fruit as 10%, 30% or 100% of diet by | | | | | | | | | | |
| | BEE | Small mammal | 1.4 | 0.22 | 10 | 440 | 0.0032 | 0.0005 | 0.023 | I / I |
| Consumption of Contaminated Insects as 10%, 30% or 100% of diet by | | | | | | | | | | |
| | BEE | Small mammal | 28 | 3.1 | 278 | 440 | 0.063 | 0.0070 | 0.63 | I / **Po** |
| | BEE | Small bird | 45 | 5.0 | 452 | 126 | 0.36 | 0.040 | **3.6** | I / **Po** |
| Consumption of Contaminated Small Mammal as 10%, 30% or 100% of diet by | | | | | | | | | | |
| | BEE | Carnivorous mammal | 2.5 | 0.84 | 8.4 | 440 | 0.0057 | 0.0019 | 0.019 | I / **Po** |
| | BEE | Carnivorous bird | 3.9 | 1.3 | 13 | 126 | 0.031 | 0.010 | 0.10 | I / **Po** |
| **Chronic Consumption of Contaminated Fruit as 10%, 30% or 100% of Diet by Receptor** | | | | | | | | | | |
| On-site | Acid | Small mammal | 0.55 | 0.056 | 6.8 | 22 | 0.025 | 0.0025 | 0.31 | I / **Po** |
| | TCP | Small mammal | 0.55 | 0.056 | 6.8 | 12 | 0.046 | 0.005 | 0.57 | I / **Po** |
| Off-site | Acid | Small mammal | 0.0024 | 0.0001 | 0.056 | 22 | 0.0001 | 6E-06 | 0.0026 | HI / HI |
| | TCP | Small mammal | 0.0024 | 0.0001 | 0.056 | 12 | 0.0002 | 1E-05 | 0.0047 | HI / HI |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable.
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.
Hazard Quotients greater than 0.1 are shaded. Hazard Quotients greater than one are **bolded.**
[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.

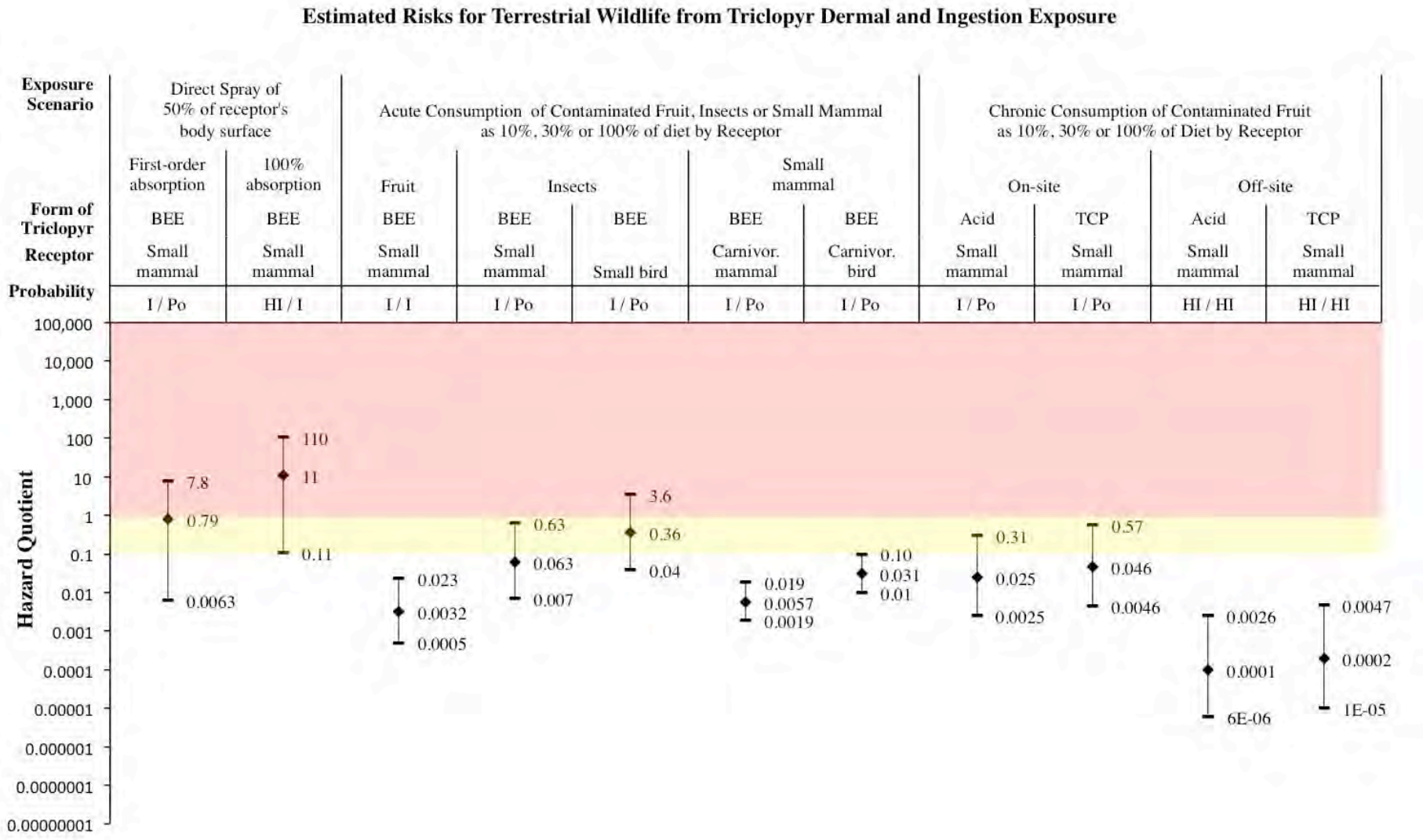



**Figure 4-9**: Estimated risks for terrestrial wildlife from triclopyr dermal and ingestion exposures. See Table 4-21 above for data used to create this chart and definitions of terminology and abbreviations used.

**Table 4-22: Estimated Risks for Small Mammals Drinking Triclopyr-Contaminated Water**

| Scenario | Form of Triclopyr[1] | Dose (mg/kg body weight/event) Central | Lower | Upper | TRV (mg/kg-day) | Hazard Quotients Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Accidental Spills** | | | | | | | | | |
| **Spill to a 5-100 L Puddle/Pool of One Gallon of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 1,062 | 133 | 26,553 | 440 | **2.4** | 0.30 | **60** | I / I |
| **Spill to Woodland Creek of 1-20 Gallons of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 6,248 | 8 | 156,195 | 440 | **14** | 0.018 | **355** | I / I |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0002 | 9E-08 | 0.018 | 440 | 5E-07 | 2E-10 | 4E-05 | **Pr / Pr** |
| | Acid | 0.018 | 6E-07 | 0.14 | 440 | 4E-05 | 1E-09 | 0.0003 | **Pr / Pr** |
| | TCP | 0.0005 | 6E-09 | 0.016 | 25 | 2E-05 | 2E-10 | 0.0007 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0002 | 5E-12 | 0.035 | 22 | 9E-06 | 2E-13 | 0.002 | **Pr / Pr** |
| | TCP | 1E-05 | 7E-14 | 0.0012 | 12 | 8E-07 | 6E-15 | 1E-04 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0001 | 4E-08 | 0.0088 | 440 | 3E-07 | 1E-10 | 2E-05 | **Pr / Pr** |
| | Acid | 0.0088 | 3E-07 | 0.070 | 440 | 2E-05 | 7E-10 | 0.0002 | **Pr / Pr** |
| | TCP | 0.0003 | 3E-09 | 0.0082 | 25 | 1E-05 | 1E-10 | 0.0003 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 1E-04 | 2E-12 | 0.018 | 22 | 4E-06 | 1E-13 | 0.0008 | **Pr / Pr** |
| | TCP | 5E-06 | 4E-14 | 0.0006 | 12 | 4E-07 | 3E-15 | 5E-05 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| Peak runoff[3] | BEE | 6E-05 | 2E-08 | 0.0044 | 440 | 1E-07 | 5E-11 | 1E-05 | **Pr / Pr** |
| | Acid | 0.0044 | 1E-07 | 0.035 | 440 | 1E-05 | 3E-10 | 8E-05 | **Pr / Pr** |
| | TCP | 0.0001 | 1E-09 | 0.0041 | 25 | 5E-06 | 6E-11 | 0.0002 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 5E-05 | 1E-12 | 0.0088 | 22 | 2E-06 | 5E-14 | 0.0004 | **Pr / Pr** |
| | TCP | 2E-06 | 2E-14 | 0.0003 | 12 | 2E-07 | 1E-15 | 2E-05 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| Peak runoff[3] | BEE | 7E-05 | 2E-08 | 0.0050 | 440 | 2E-07 | 6E-11 | 1E-05 | **Pr / Pr** |
| | Acid | 0.0050 | 2E-07 | 0.040 | 440 | 1E-05 | 4E-10 | 9E-05 | **Pr / Pr** |
| | TCP | 0.0001 | 2E-09 | 0.0046 | 25 | 6E-06 | 7E-11 | 0.0002 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 6E-05 | 1E-12 | 0.0099 | 22 | 3E-06 | 6E-14 | 0.0005 | **Pr / Pr** |
| | TCP | 3E-06 | 2E-14 | 0.0003 | 12 | 6E-06 | 2E-09 | 0.0004 | **Pr / Pr** |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable

[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.

[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.
[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.
[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

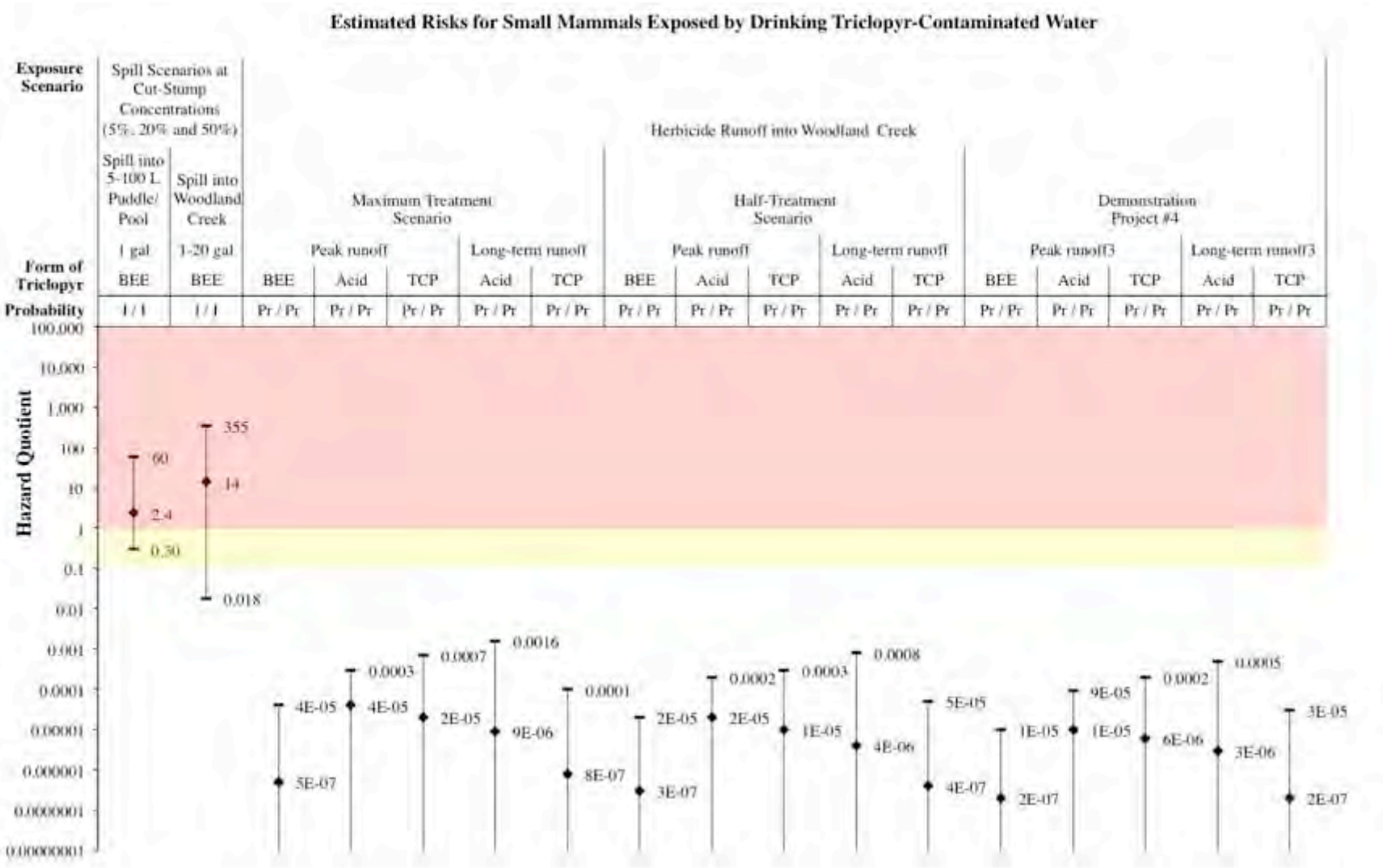



**Figure 4-10:** Estimated risks for small mammals exposed by drinking triclopyr-contaminated water. See Table 4-22 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$; bars without numbers on the top have Upper HQs greater than 100,000.

### Table 4-23: Estimated Risks for Carnivorous Mammals Drinking Triclopyr-Contaminated Water

| Scenario | Form of Triclopyr[1] | Dose (mg/kg body weight/event) Central | Lower | Upper | TRV (mg/kg-day) | Hazard Quotients Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Accidental Spills** | | | | | | | | | |
| **Spill to a 5-100 L Puddle/Pool of One Gallon of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 611 | 76 | 15,287 | 20 | **31** | **3.8** | **764** | I / I |
| **Spill to Woodland Creek of 1-20 Gallons of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 3,597 | 4.5 | 89,923 | 20 | **180** | 0.22 | **4,496** | I / I |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0001 | 5E-08 | 0.010 | 20 | 7E-06 | 3E-09 | 0.0005 | **Pr / Pr** |
| | Acid | 0.010 | 3E-07 | 0.081 | 20 | 0.0005 | 2E-08 | 0.0040 | **Pr / Pr** |
| | TCP | 0.0003 | 3E-09 | 0.0094 | 25 | 1E-05 | 1E-10 | 0.0004 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0001 | 3E-12 | 0.020 | 1 | 0.0001 | 3E-12 | 0.020 | **Pr / Pr** |
| | TCP | 6E-06 | 4E-14 | 0.0007 | 12 | 5E-07 | 3E-15 | 6E-05 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| Peak runoff[3] | BEE | 7E-05 | 3E-08 | 0.0051 | 20 | 3E-06 | 1E-09 | 0.0003 | **Pr / Pr** |
| | Acid | 0.0051 | 2E-07 | 0.040 | 20 | 0.0003 | 8E-09 | 0.0020 | **Pr / Pr** |
| | TCP | 0.0002 | 2E-09 | 0.0047 | 25 | 6E-06 | 7E-11 | 0.0002 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 6E-05 | 1E-12 | 0.010 | 1 | 6E-05 | 1E-12 | 0.010 | **Pr / Pr** |
| | TCP | 3E-06 | 2E-14 | 0.0003 | 12 | 2E-07 | 2E-15 | 3E-05 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| Peak runoff[3] | BEE | 3E-05 | 1E-08 | 0.0025 | 20 | 2E-06 | 6E-10 | 0.0001 | **Pr / Pr** |
| | Acid | 0.0025 | 8E-08 | 0.020 | 20 | 0.0001 | 4E-09 | 0.0010 | **Pr / Pr** |
| | TCP | 8E-05 | 8E-10 | 0.0024 | 25 | 3E-06 | 3E-11 | 9E-05 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 3E-05 | 7E-13 | 0.0051 | 1 | 3E-05 | 7E-13 | 0.0051 | **Pr / Pr** |
| | TCP | 1E-06 | 1E-14 | 0.0002 | 12 | 1E-07 | 9E-16 | 1E-05 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| Peak runoff[3] | BEE | 4E-05 | 1E-08 | 0.0029 | 20 | 2E-06 | 7E-10 | 0.0001 | **Pr / Pr** |
| | Acid | 0.0029 | 1E-07 | 0.023 | 20 | 0.0001 | 5E-09 | 0.0011 | **Pr / Pr** |
| | TCP | 9E-05 | 1E-09 | 0.0027 | 25 | 3E-06 | 4E-11 | 0.0001 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 3E-05 | 8E-13 | 0.0057 | 1 | 3E-05 | 8E-13 | 0.0057 | **Pr / Pr** |
| | TCP | 2E-06 | 1E-14 | 0.0002 | 12 | 3E-06 | 1E-09 | 0.0002 | **Pr / Pr** |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.
[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.
[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.

[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

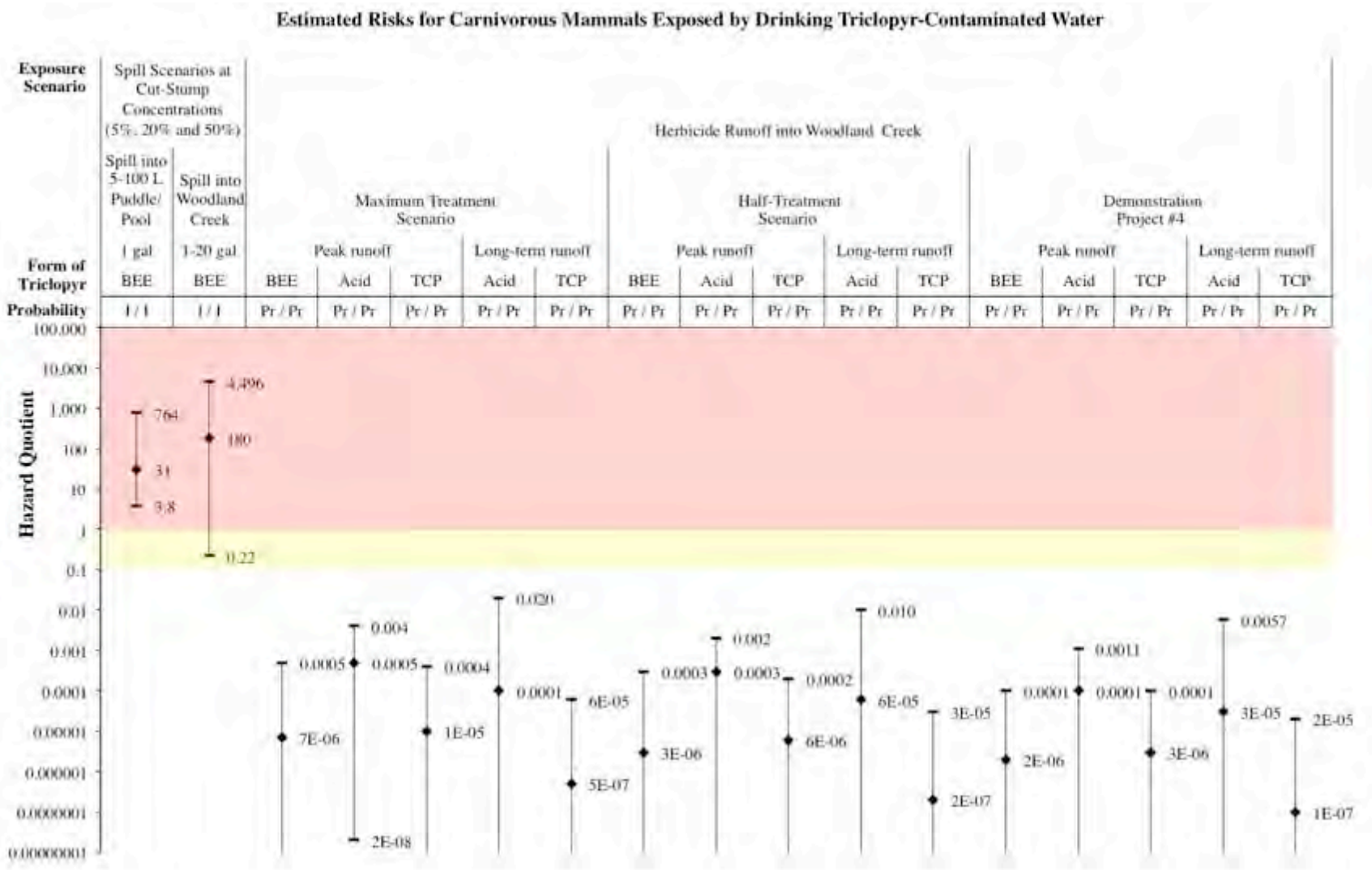



**Figure 4-11**: Estimated risks for carnivorous mammals exposed by drinking triclopyr-contaminated water. See Table 4-23 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$.

**Table 4-24: Estimated Risks for Small Birds Drinking Triclopyr-Contaminated Water**

| Scenario | Form of Triclopyr[1] | Dose (mg/kg body weight/event) | | | TRV | Hazard Quotients | | | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | (mg/kg-day) | Central | Lower | Upper | |
| **Accidental Spills** | | | | | | | | | |
| **Spill to a 5-100 L Puddle/Pool of One Gallon of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 1,957 | 245 | 48,914 | 126 | **16** | **1.9** | **388** | I / I |
| **Spill to Woodland Creek of 1-20 Gallons of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 115 | 14 | 2,877 | 126 | 0.91 | 0.11 | **23** | I / I |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0004 | 2E-07 | 0.032 | 126 | 3E-06 | 1E-09 | 0.0003 | **Pr / Pr** |
| | Acid | 0.032 | 1E-06 | 0.26 | 126 | 0.0003 | 9E-09 | 0.0021 | **Pr / Pr** |
| | TCP | 0.0010 | 1E-08 | 0.030 | 11.6 | 8E-05 | 9E-10 | 0.0026 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0004 | 9E-12 | 0.065 | 7.5 | 5E-05 | 1E-12 | 0.0086 | **Pr / Pr** |
| | TCP | 2E-05 | 1E-13 | 0.0022 | 12 | 2E-06 | 1E-14 | 0.0002 | **Pr / Pr** |
| **Half-Treatment Scenario[4]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0002 | 8E-08 | 0.016 | 126 | 2E-06 | 6E-10 | 0.0001 | **Pr / Pr** |
| | Acid | 0.016 | 5E-07 | 0.129 | 126 | 0.0001 | 4E-09 | 0.0010 | **Pr / Pr** |
| | TCP | 0.0005 | 5E-09 | 0.015 | 11.6 | 4E-05 | 5E-10 | 0.0013 | **Pr / Pr** |
| Long-term runoff [3] | Acid | 0.0002 | 4E-12 | 0.032 | 7.5 | 2E-05 | 6E-13 | 0.0043 | **Pr / Pr** |
| | TCP | 9E-06 | 7E-14 | 0.0011 | 12 | 8E-07 | 6E-15 | 9E-05 | **Pr / Pr** |
| **Quarter-Treatment Scenario[5]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0001 | 4E-08 | 0.0081 | 126 | 9E-07 | 3E-10 | 6E-05 | **Pr / Pr** |
| | Acid | 0.0081 | 3E-07 | 0.065 | 126 | 6E-05 | 2E-09 | 0.0005 | **Pr / Pr** |
| | TCP | 0.0002 | 3E-09 | 0.0076 | 11.6 | 2E-05 | 2E-10 | 0.0007 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 9E-05 | 2E-12 | 0.016 | 7.5 | 1E-05 | 3E-13 | 0.0022 | **Pr / Pr** |
| | TCP | 5E-06 | 3E-14 | 0.0005 | 12 | 4E-07 | 3E-15 | 4E-05 | **Pr / Pr** |
| **Demonstration Project #4[6]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0001 | 5E-08 | 0.0091 | 126 | 1E-06 | 4E-10 | 7E-05 | **Pr / Pr** |
| | Acid | 0.0091 | 3E-07 | 0.073 | 126 | 7E-05 | 2E-09 | 0.0006 | **Pr / Pr** |
| | TCP | 0.0003 | 3E-09 | 0.0085 | 11.6 | 2E-05 | 3E-10 | 0.0007 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0001 | 2E-12 | 0.018 | 7.5 | 1E-05 | 3E-13 | 0.0024 | **Pr / Pr** |
| | TCP | 5E-06 | 4E-14 | 0.0006 | 12 | 1E-05 | 4E-09 | 0.0008 | **Pr / Pr** |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.

[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.
[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.
[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

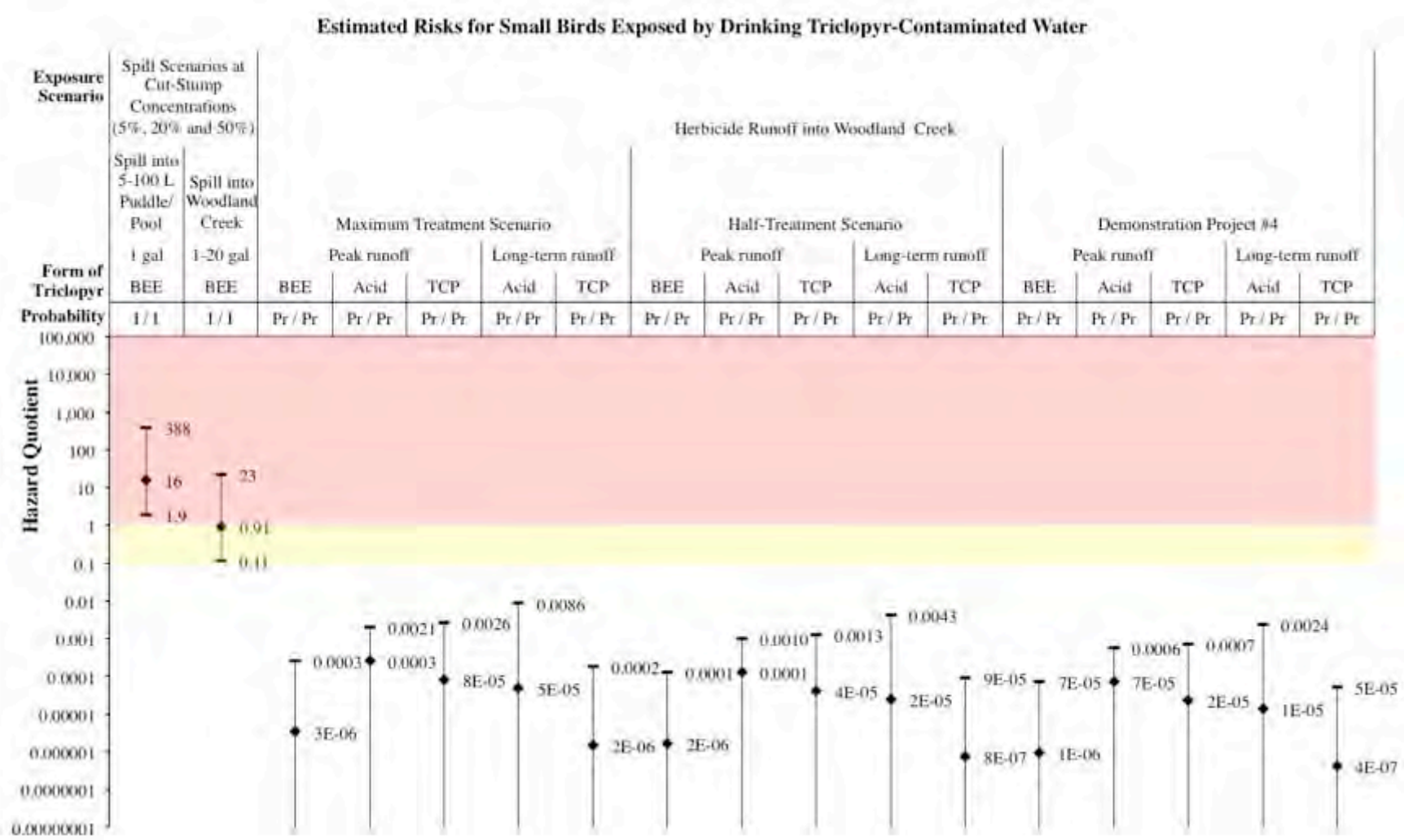



**Figure 4-12**: Estimated risks for small birds exposed by drinking triclopyr-contaminated water. See Table 4-24 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$.

**Table 4-25: Estimated Risks for Large Birds Drinking Triclopyr-Contaminated Water**

| Scenario | Form of Triclopyr[1] | Dose (mg/kg body weight/event) Central | Lower | Upper | TRV (mg/kg-day) | Hazard Quotients Central | Lower | Upper | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Accidental Spills** | | | | | | | | | |
| **Spill to a 5-100 L Puddle/Pool of One Gallon of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 271 | 34 | 6,773 | 126 | **2.2** | 0.27 | **54** | I / I |
| **Spill to Woodland Creek of 1-20 Gallons of Herbicide at Cut-Stump Concentrations (5%, 20% and 50%)** | | | | | | | | | |
| | BEE | 16 | 2.0 | 398 | 126 | 0.13 | 0.016 | **3.2** | I / I |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff[3] | BEE | 6E-05 | 2E-08 | 0.0045 | 126 | 5E-07 | 2E-10 | 4E-05 | **Pr / Pr** |
| | Acid | 0.0045 | 1E-07 | 0.036 | 126 | 4E-05 | 1E-09 | 0.0003 | **Pr / Pr** |
| | TCP | 0.0001 | 1E-09 | 0.0042 | 11.6 | 1E-05 | 1E-10 | 0.0004 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 5E-05 | 1E-12 | 0.0090 | 7.5 | 7E-06 | 2E-13 | 0.0012 | **Pr / Pr** |
| | TCP | 2E-06 | 2E-14 | 0.0003 | 12 | 2E-07 | 2E-15 | 2E-05 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| Peak runoff[3] | BEE | 3E-05 | 1E-08 | 0.0022 | 126 | 2E-07 | 9E-11 | 2E-05 | **Pr / Pr** |
| | Acid | 0.0022 | 7E-08 | 0.018 | 126 | 2E-05 | 6E-10 | 0.0001 | **Pr / Pr** |
| | TCP | 7E-05 | 7E-10 | 0.0021 | 11.6 | 6E-06 | 6E-11 | 0.0002 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 2E-05 | 6E-13 | 0.0045 | 7.5 | 3E-06 | 8E-14 | 0.0006 | **Pr / Pr** |
| | TCP | 1E-06 | 9E-15 | 0.0001 | 12 | 1E-07 | 8E-16 | 1E-05 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| Peak runoff[3] | BEE | 1E-05 | 6E-09 | 0.0011 | 126 | 1E-07 | 4E-11 | 9E-06 | **Pr / Pr** |
| | Acid | 0.0011 | 4E-08 | 0.0090 | 126 | 9E-06 | 3E-10 | 7E-05 | **Pr / Pr** |
| | TCP | 3E-05 | 4E-10 | 0.0010 | 11.6 | 3E-06 | 3E-11 | 9E-05 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 1E-05 | 3E-13 | 0.0022 | 7.5 | 2E-06 | 4E-14 | 0.0003 | **Pr / Pr** |
| | TCP | 6E-07 | 5E-15 | 7E-05 | 12 | 5E-08 | 4E-16 | 6E-06 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| Peak runoff[3] | BEE | 2E-05 | 6E-09 | 0.0013 | 126 | 1E-07 | 5E-11 | 1E-05 | **Pr / Pr** |
| | Acid | 0.0013 | 4E-08 | 0.010 | 126 | 1E-05 | 3E-10 | 8E-05 | **Pr / Pr** |
| | TCP | 4E-05 | 4E-10 | 0.0012 | 11.6 | 3E-06 | 4E-11 | 0.0001 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 1E-05 | 3E-13 | 0.0025 | 7.5 | 2E-06 | 5E-14 | 0.0003 | **Pr / Pr** |
| | TCP | 7E-07 | 5E-15 | 8E-05 | 12 | 1E-06 | 5E-10 | 0.0001 | **Pr / Pr** |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.
[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.
[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

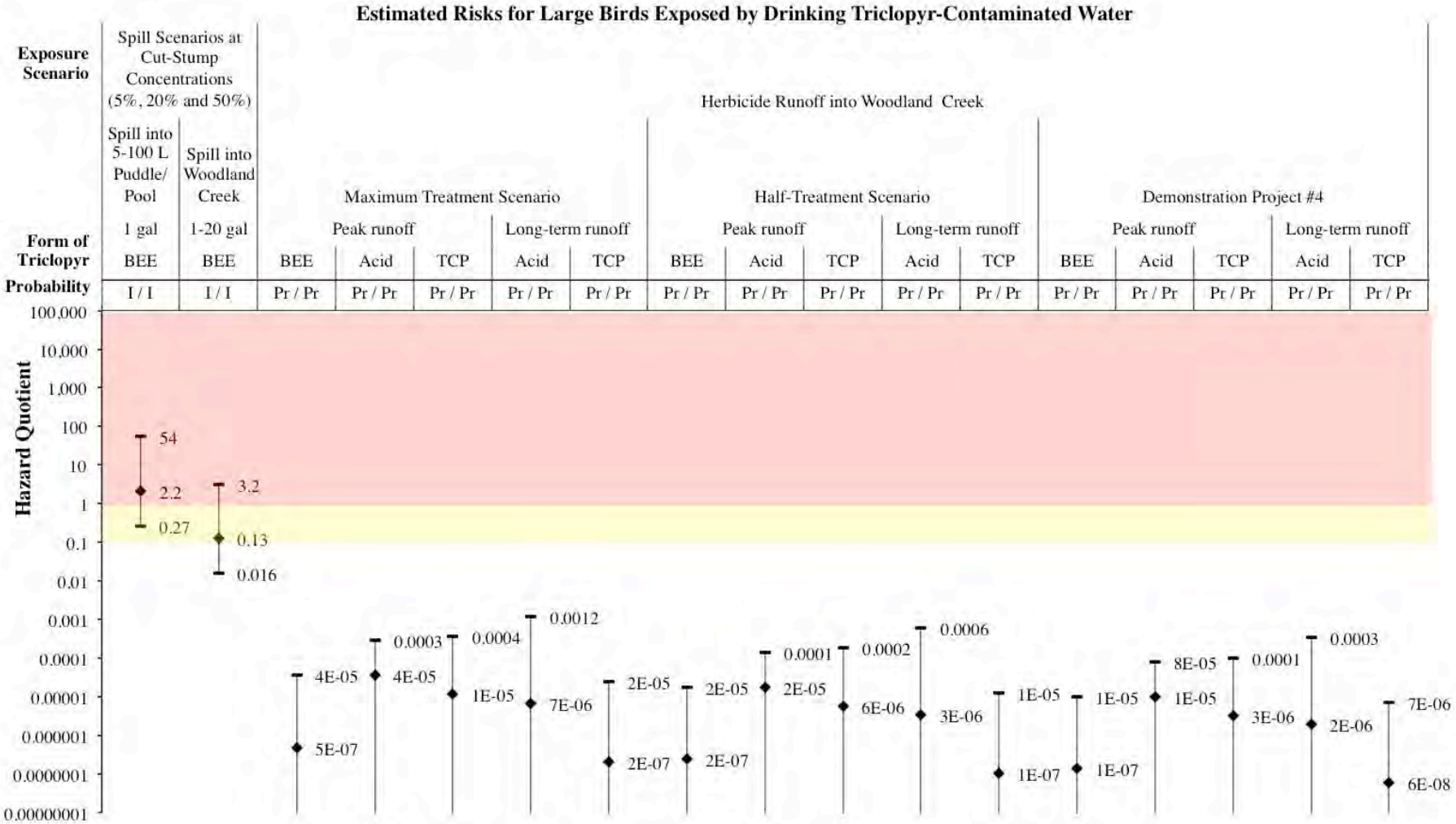



**Figure 4-13**: Estimated risks for large birds exposed by drinking triclopyr-contaminated water. See Table 4-25 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$.

#### *4.5.5.A Terrestrial Plants*

For terrestrial plants, unintended application will result in an exposure equivalent to the application rate. With the exception of monocots and conifers, most plants that are sprayed directly with triclopyr at or near the recommended range of application rates will be damaged. Triclopyr is persistent enough and absorbed through the roots sufficiently that there may be some residual herbicidal activity in treated areas. This factor should be accounted for if replanting of native plants is being considered.

At least 22 special-status plant species potentially occur in the general vicinity of Mount Sutro, based on the known range of these species; however, the Reserve provides suitable habitat for only two of these species—gumplant (*Grindelia hirsutula* var. maritima) and coastal triquetrella (*Triquetrella californica*). [158] If applicators are advised in recognizing these plants, risk to these two species can be minimized.

#### *4.5.5.B Aquatic Wildlife*

The concentrations of triclopyr in water for aquatic life are the same as those used in the human and terrestrial exposure estimates for drinking water (see Tables 4-13 and 4-15 through 4-17). Acute exposure estimates due to spills of Garlon 4 Ultra are compared to TRVs for triclopyr BEE, the active ingredient. Exposures as a result of contaminated rainfall runoff are compared to TRVs for triclopyr BEE and its degradation products, triclopyr acid and 3,5,6-trichloro-2-pyridinol (TCP). For chronic (long-term) runoff scenarios, risk evaluations are for triclopyr acid and TCP only, since triclopyr BEE is assumed to be completely transformed into triclopyr acid and TCP in the environment during the time frame over which long-term runoff might occur.[93] Hazard quotients for spill scenarios for amphibians, fish, aquatic invertebrates and aquatic plants are summarized in Figure 4-14. Hazard quotients for non-spill scenarios for amphibians and fish are summarized in Tables 4-26 and 4-27 and Figure 4-15 and 4-16; for aquatic invertebrates in Table 4-28 and Figures 4-17 and 4-18; and for aquatic plants (algae only) in Table 4-29 and Figures 4-19 and 4-20. See Section 0 for the derivation of the TRVs for aquatic animals.

Spills represent the highest potential risk to aquatic wildlife, with estimated doses thousands to millions of times the relevant TRVs for a one-gallon spill into a small (5 Liter) pool or puddle, or for a 20-gallon spill into Woodland Creek. Hazard Quotients greater than 1.0 would result from spills of one gallon of herbicide even at the lowest cut-stump concentrations—mixed to just five percent Garlon 4 Ultra. Spills are considered **Highly Improbable**, as long as the applicator guidelines in Section 2.5.1 are followed. Risks to aquatic life could be reduced by limiting use of triclopyr to areas distant from water bodies.

Runoff scenarios are the only **Probable** exposures for aquatic wildlife, and most HQs for these scenarios are substantially lower than the TRVs. Aquatic plants are relatively more likely to be adversely affected by runoff than fish, amphibians or aquatic invertebrates, primarily because of lower TRVs. Risks from runoff can be minimized by treating fewer acres in a given watershed, particularly the Woodland Creek watershed, at the same time. Note that runoff to Woodland Creek is not applicable to Demonstration Project 1, which does not drain to the creek.

Because of lack of data, it was not possible to estimate levels of triclopyr in puddles or pools from overland flow, but concentrations of triclopyr may be high enough in puddles/pools

adjacent to treatment sites that TRVs for amphibians, aquatic invertebrates, and plants could be exceeded. Risks could be reduced by filling in ruts and depressions near treatment sites.

**Most Likely Exposures:** The aquatic scenarios considered **Probable** (for both the Main Project and Demonstration Projects) are the peak and long-term runoff scenarios. Exposures from runoff scenarios exceed TRVs for the following species in this risk assessment:

1. **Sensitive species of amphibians exposed to herbicide runoff in Woodland Creek (Probable** for the Main Project or Demonstration Project 4; N/A to Demonstration Project 1).
   **Peak runoff:** Central dose estimates for triclopyr BEE and TCP are below the TRV for amphibians, even for the Maximum treatment scenario of 4 lb/acre of triclopyr BEE. The highest Central estimate of peak-runoff risk for amphibians is two percent of the TRV for TCP. However, worst-case (Upper) estimates do approach TRVs, and the Upper estimate for triclopyr BEE exceeds the TRV for amphibians in the Maximum treatment scenario in which four pounds per acre are applied. The highest Upper estimate is for exposure to triclopyr BEE at 1.2 times the TRV for amphibians.
   **Long-term runoff:** Estimated amphibian exposures due to long-term runoff to Woodland Creek are below levels of concern in even the Maximum treatment scenario of four pounds per acre of triclopyr BEE applied.

2. **Sensitive species of fish exposed to herbicide runoff at wastewater treatment plant outfalls (Probable** for the Main Project or Demonstration Projects)
   **Peak runoff:** Estimated fish exposures due to peak runoff to wastewater treatment plants are below levels of concern in even the Maximum treatment scenario of four pounds per acre of triclopyr BEE applied. The highest Central exposure estimate for fish is 0.15 percent of the TRV for triclopyr BEE based on runoff to Oceanside WWTP after four pounds per acre are applied to all acres that drain to Oceanside WWTP. The highest worst-case (Upper) estimate for fish is one percent of the TRV for triclopyr BEE, based on the same scenario.
   **Long-term runoff:** Long-term runoff to wastewater treatment plants was not considered because peak runoff estimates for even the Maximum treatment scenario of four pounds per acre of triclopyr BEE applied are below levels of concern.

3. **Sensitive species of aquatic invertebrates exposed to herbicide runoff in Woodland Creek (Probable** for the Main Project or Demonstration Project 4; N/A to Demonstration Project 1).
   **Peak runoff:** If four pounds per acre of triclopyr is applied to all acres that drain to Woodland Creek (the Maximum treatment scenario), peak runoff exposures are below levels of concern for any of the most-likely (Central) estimates. However, worst-case (Upper) estimates exceed the acute TRV for aquatic invertebrates exposed to triclopyr BEE at 2.7 times the TRV. Upper estimates of TCP exposure are 20 percent of the TRV. Upper estimates for triclopyr acid are below levels of concern.
   **Long-term runoff:** Estimated exposures due to long-term runoff to Woodland Creek are below levels of concern for triclopyr BEE, triclopyr acid or TCP in even the Maximum

treatment scenario of four pounds per acre of triclopyr applied.

4. **Sensitive species of aquatic invertebrates exposed to herbicide runoff at wastewater treatment plant outfalls (Probable** for the Main Project or Demonstration Projects)
   **Peak runoff:** Estimated exposures are below levels of concern in even the Maximum treatment scenario of four pounds per acre of triclopyr BEE applied. The highest Central exposure estimate for aquatic invertebrate is 0.31 percent of the TRV for triclopyr BEE based on runoff to Oceanside WWTP after four pounds per acre are applied to all acres that drain to Oceanside WWTP. The highest Upper estimate for aquatic invertebrates is two percent of the TRV for triclopyr BEE, based on the same scenario.
   **Long-term runoff:** Long-term runoff to wastewater treatment plants was not considered because peak runoff estimates for even the Maximum treatment scenario of four pounds per acre of triclopyr BEE applied are below levels of concern.

5. **Sensitive species of aquatic plants exposed to herbicide runoff in Woodland Creek (Probable** for the Main Project or Demonstration Project 4; N/A to Demonstration Project 1).
   **Peak runoff:** Most likely (Central) estimates suggest that aquatic plants would be exposed to triclopyr BEE and triclopyr acid in concentrations approaching, or in the Maximum treatment scenario exceeding, levels of concern in every treatment scenario evaluated. Using Upper estimates, triclopyr BEE and triclopyr acid exposure are estimated to exceed TRVs in every treatment scenario. The Maximum treatment scenario Central estimate exceeds the level of concern for triclopyr BEE at 1.1 times the TRV. The Upper exposure estimate for this scenario is 86 times the level of concern. Half or Quarter treatment scenarios lead to Upper exposure estimates that approach the TRV for triclopyr BEE (for both scenarios) and TCP (for Half treatment scenario). If the one-acre Demonstration Project #4, is treated with four pounds per acre, Central estimates for triclopyr BEE and triclopyr acid approach the level of concern at 32 percent and 15 percent of the TRV, respectively, and Upper estimates are 24 times and 1.2 times the respective TRVs.
   **Long-term runoff:** The most likely (Central) estimate are below levels of concern for triclopyr acid or TCP assuming the Maximum treatment scenario—four pounds per acre applied to all acres that drain to the creek—or for any less-intensive treatment scenario. However, the worst-case (Upper) estimate in the Maximum treatment scenario slightly exceeds levels of concern at 104 percent of the TRV for triclopyr acid; TCP would still be well below levels of concern in the Upper estimate. For Demonstration Project 4 and the Half and Quarter treatment scenarios, Upper estimates for triclopyr acid are 29 percent, 52 percent and 26 percent of the TRV, respectively.

6. **Sensitive species of aquatic plants exposed to herbicide runoff at wastewater treatment plant outfalls (Probable** for the Main Project or Demonstration Projects)
   **Peak runoff:** Central estimates are below levels of concern in even the Maximum treatment scenario of four pounds per acre of triclopyr applied. The highest Central exposure estimate for aquatic plant is 9.9 percent of the TRV for triclopyr BEE based on runoff to Oceanside WWTP after four pounds per acre are applied to all acres that drain to Oceanside WWTP. The highest worst-case (Upper) estimate for aquatic plants is 66

percent of the TRV for triclopyr BEE, based on the same scenario, 19 percent of the TRV for the Demonstration Project #4 treatment scenario, and16 percent and 33 percent of the TRV for the Half and Quarter treatment scenarios.
**Long-term runoff:** Long-term runoff to wastewater treatment plants was not considered because peak runoff estimates for even the Maximum treatment scenario of four pounds per acre of triclopyr BEE applied are below levels of concern.

No other **Probable** or **Possible** exposure estimate exceeds 10 percent of the relevant TRV.

**Highest Exposures:** It is also useful to consider the scenarios that yield the highest exposures, regardless of their probability, to evaluate the potential need for additional precautions that might be needed to protect aquatic wildlife. The highest hazard quotients calculated for **Highly Improbable** spills of triclopyr into a puddle or pool, or into Woodland Creek, indicate that amphibians, aquatic invertebrates or aquatic plants could be exposed to concentrations of triclopyr BEE exceeding levels of concern by 533 times the acute TRV at minimum, given best-case (Lower) assumptions such as a one-gallon spill of triclopyr of a five percent solution. All Central estimates were thousands of times the TRV for any of the aquatic wildlife evaluated. Applicators should do everything possible to minimize the potential for an acute spill of triclopyr in or near water bodies.

1. **Spills of one gallon of cut-stump solutions to puddles or pools (Highly Improbable** for the Main Project or for the Demonstration Projects).
   Spills to puddles or pools represented the highest exposures of any kind. The most likely (Central) estimate, though **Highly Improbable** to occur, leads to an estimated dose 72,551 times the level of concern for amphibians, and the equivalent risk estimate for aquatic invertebrates and aquatic plants is higher. A best-case (Lower) estimate of a one-gallon spill of five percent triclopyr solution to a 100-liter pool/puddle leads to an estimated dose 9,069 times the TRV for amphibians, which was lower than the equivalent risk estimate for aquatic invertebrates and aquatic plants.

2. **Spills of one gallon of cut-stump solution to Woodland Creek (Highly Improbable** for the Main Project or Demonstration Project 4; not applicable to Demonstration Project 1).
   A one-gallon spill to Woodland Creek results in estimated doses 4,268 times (Central estimate) or 533 times (Lower estimate) the TRV for amphibians; HQs for aquatic invertebrates and aquatic plants are higher still.

3. **Spills of 20 gallons of cut-stump solution to Woodland Creek (Highly Improbable** for the Main Project or Demonstration Project 4; N/A to Demonstration Project 1).
   Twenty-gallon spills to Woodland Creek were calculated as a worst-case scenario that would only occur if a vehicle carrying such a volume of herbicide were to spill into Woodland Creek. All estimated doses—Upper, Central and Lower—were found to be thousands of times the TRVs for all three aquatic wildlife categories evaluated: amphibians, aquatic invertebrates and aquatic plants. The lowest of the best-case (Lower) estimated doses (which assumes a spill of triclopyr at five percent concentration) is still

10,669 times the TRV for amphibians; estimated risks to aquatic invertebrates and aquatic plants is higher still.

We conclude that if all 48 accessible acres are treated with triclopyr BEE at 4 lb/acre (the Maximum treatment scenario), it is likely that any algae in Woodland Creek would be adversely affected by contaminated runoff, given most likely (Central) assumptions. In the Half and Quarter treatment scenarios, however, only the worst-case (Upper) estimates exceed or approach levels of concern.

Demonstration Project #4 is limited to two acres treated, with triclopyr runoff approaching levels of concern at 75 percent of the TRV for aquatic plants, given worst-case (Upper) assumptions for the Maximum treatment scenario.

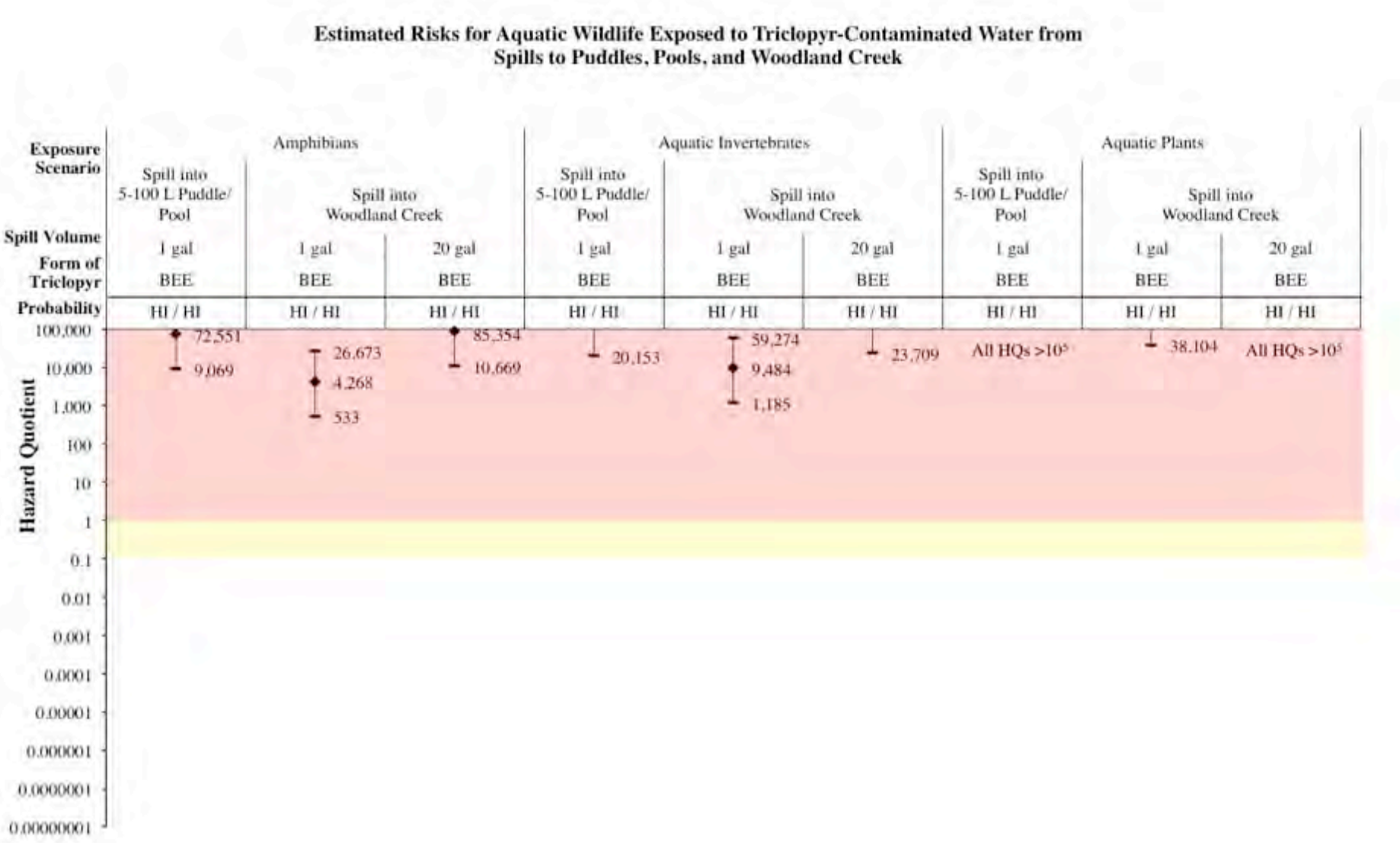



**Figure 4-14**: Estimated risks for aquatic wildlife exposed to triclopyr-contaminated water from spills to puddles, pools and Woodland Creek. See Tables 4-26, 4-28, and 4-29 below for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the top have a HQs greater than 100,000.

**Table 4-26: Estimated Risks for Sensitive Amphibians Exposed to Triclopyr-Contaminated Water**

| Scenario | Form of Triclopyr[1] | Concentration (mg/L) Central | Lower | Upper | Hazard Quotients Central | Lower | Upper | TRV (mg/L) | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Accidental Spills** | | | | | | | | | |
| **Spills of Cut-Stump Solutions (5%, 20% or 50%)** | | | | | | | | | |
| Spill into puddle/pool | 1 gal | 7,255 | 907 | 181,377 | **72,551** | **9,069** | **1,813,772** | 0.1 | HI / HI |
| Spill into Woodland Creek | 1 gal | 427 | 53 | 2,667 | **4,268** | **533** | **26,673** | 0.1 | HI / HI |
| | 20 gal | 8,535 | 1,067 | 53,346 | **85,354** | **10,669** | **533,462** | 0.1 | HI / HI |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0016 | 6E-07 | 0.12 | 0.016 | 6E-06 | **1.2** | 0.1 | **Pr / Pr** |
| | Acid | 0.12 | 4E-06 | 0.96 | 0.0010 | 3E-08 | 0.0077 | 125 | **Pr / Pr** |
| | TCP | 0.0036 | 4E-08 | 0.11 | 0.020 | 2E-07 | 0.62 | 0.18 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0013 | 3E-11 | 0.24 | 0.00001 | 3E-13 | 0.0019 | 125 | **Pr / Pr** |
| | TCP | 7E-05 | 5E-13 | 0.008 | 0.0004 | 3E-12 | 0.044 | 0.18 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0008 | 3E-07 | 0.060 | 0.008 | 3E-06 | 0.6 | 0.1 | **Pr / Pr** |
| | Acid | 0.0600 | 2E-06 | 0.48 | 0.0005 | 2E-08 | 0.004 | 125 | **Pr / Pr** |
| | TCP | 0.0018 | 2E-08 | 0.056 | 0.010 | 1E-07 | 0.31 | 0.18 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0007 | 2E-11 | 0.12 | 5E-06 | 1E-13 | 0.0010 | 125 | **Pr / Pr** |
| | TCP | 3E-05 | 2E-13 | 0.0040 | 0.00019 | 1E-12 | 0.0222 | 0.18 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0004 | 2E-07 | 0.030 | 0.0040 | 2E-06 | 0.3 | 0.1 | **Pr / Pr** |
| | Acid | 0.0300 | 1E-06 | 0.24 | 0.0002 | 8E-09 | 0.002 | 125 | **Pr / Pr** |
| | TCP | 0.0009 | 1E-08 | 0.028 | 0.0050 | 6E-08 | 0.16 | 0.18 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0003 | 8E-12 | 0.060 | 0.000003 | 7E-14 | 0.0005 | 125 | **Pr / Pr** |
| | TCP | 1E-05 | 1E-13 | 0.002 | 0.00009 | 7E-13 | 0.011 | 0.18 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0005 | 2E-07 | 0.034 | 0.0045 | 2E-06 | 0.34 | 0.1 | **Pr / Pr** |
| | Acid | 0.034 | 1E-06 | 0.27 | 0.0003 | 9E-09 | 0.002 | 125 | **Pr / Pr** |
| | TCP | 0.0010 | 1E-08 | 0.032 | 0.0056 | 6E-08 | 0.18 | 0.18 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0004 | 9E-12 | 0.068 | 3E-06 | 7E-14 | 0.0005 | 125 | **Pr / Pr** |
| | TCP | 1E-05 | 1E-13 | 0.00226 | 0.00011 | 8E-13 | 0.013 | 0.18 | **Pr / Pr** |

TRV = Toxicity Reference Value. DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable.
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.

[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.
[3] Peak runoff to Oceanside and Southeast WWTPs was estimated using USFS/GLEAMS herbicide runoff rates and WWTP capacities. See Section 2.5.2.H for details.
[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

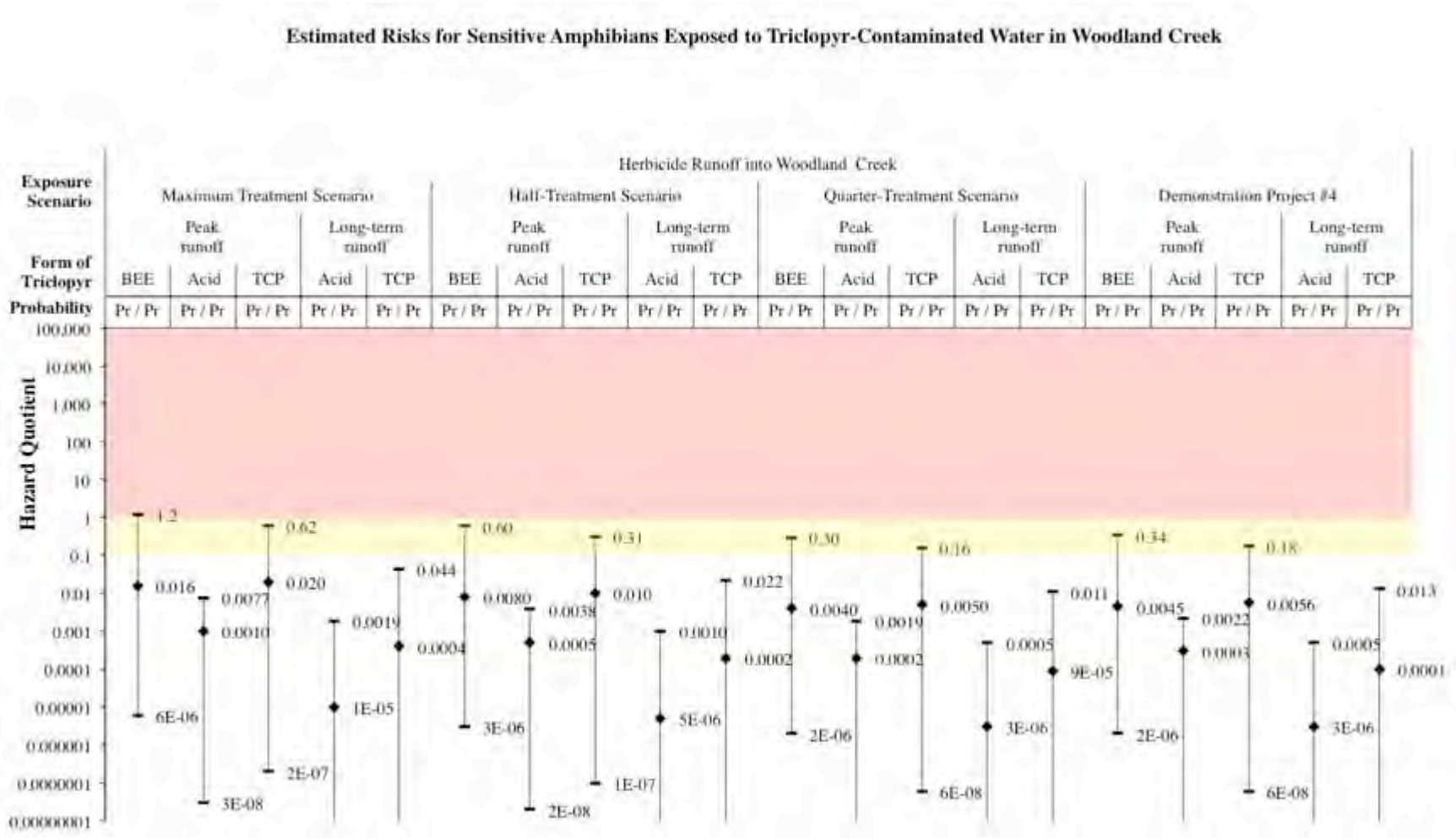



**Figure 4-15**: Estimated risks for sensitive species of amphibians exposed to triclopyr-contaminated water in Woodland Creek. See Table 4-26 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$.

## Table 4-27: Estimated Risks for Sensitive Fish Exposed to Triclopyr at Wastewater Treatment Plant Outfalls

| Scenario[1] | Form of Triclopyr[2] | Concentration (mg/L) | | | Hazard Quotients | | | TRV | Scenario Probability |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | Central | Lower | Upper | (mg/L) | (DP / Proj) |
| **Herbicide Runoff to Wastewater Treatment Plants (5-year storm)** | | | | | | | | | |
| **Maximum Treatment Scenario[3]** | | | | | | | | | |
| To Oceanside WWTP[4] | BEE | 0.0001 | 2E-06 | 0.0009 | 0.0015 | 2E-05 | 0.010 | 0.091 | **Pr / Pr** |
| | Acid | 0.0002 | 2E-05 | 0.0007 | 1E-04 | 9E-06 | 0.0003 | 2 | **Pr / Pr** |
| | TCP | 2E-05 | 5E-06 | 0.0001 | 0.0001 | 3E-05 | 0.0006 | 0.18 | **Pr / Pr** |
| To Southeast WWTP[4] | BEE | 1E-05 | 1E-07 | 9E-05 | 0.0001 | 2E-06 | 0.0010 | 0.091 | **Pr / Pr** |
| | Acid | 2E-05 | 2E-06 | 7E-05 | 9E-06 | 8E-07 | 3E-05 | 2 | **Pr / Pr** |
| | TCP | 2E-06 | 5E-07 | 1E-05 | 1E-05 | 3E-06 | 6E-05 | 0.18 | **Pr / Pr** |
| **Half Treatment Scenario[5]** | | | | | | | | | |
| To Oceanside WWTP[4] | BEE | 7E-05 | 8E-07 | 0.0005 | 0.0008 | 9E-06 | 0.0051 | 0.091 | **Pr / Pr** |
| | Acid | 1E-04 | 9E-06 | 0.0003 | 5E-05 | 4E-06 | 0.0002 | 2 | **Pr / Pr** |
| | TCP | 9E-06 | 3E-06 | 6E-05 | 5E-05 | 1E-05 | 0.0003 | 0.18 | **Pr / Pr** |
| To Southeast WWTP[4] | BEE | 7E-06 | 7E-08 | 4E-05 | 7E-05 | 8E-07 | 0.0005 | 0.091 | **Pr / Pr** |
| | Acid | 9E-06 | 8E-07 | 3E-05 | 5E-06 | 4E-07 | 2E-05 | 2 | **Pr / Pr** |
| | TCP | 9E-07 | 3E-07 | 6E-06 | 5E-06 | 1E-06 | 3E-05 | 0.18 | **Pr / Pr** |
| **Quarter Treatment Scenario[6]** | | | | | | | | | |
| To Oceanside WWTP[4] | BEE | 3E-05 | 4E-07 | 0.0002 | 0.0004 | 4E-06 | 0.0025 | 0.091 | **Pr / Pr** |
| | Acid | 5E-05 | 4E-06 | 0.0002 | 2E-05 | 2E-06 | 9E-05 | 2 | **Pr / Pr** |
| | TCP | 5E-06 | 1E-06 | 3E-05 | 3E-05 | 7E-06 | 0.0002 | 0.18 | **Pr / Pr** |
| To Southeast WWTP[4] | BEE | 3E-06 | 4E-08 | 2E-05 | 4E-05 | 4E-07 | 0.0002 | 0.091 | **Pr / Pr** |
| | Acid | 5E-06 | 4E-07 | 2E-05 | 2E-06 | 2E-07 | 8E-06 | 2 | **Pr / Pr** |
| | TCP | 4E-07 | 1E-07 | 3E-06 | 2E-06 | 7E-07 | 2E-05 | 0.18 | **Pr / Pr** |
| **Demonstration Plot #4[7]** | | | | | | | | | |
| To Oceanside WWTP[4] | BEE | 4E-05 | 4E-07 | 0.0003 | 0.0004 | 5E-06 | 0.0029 | 0.091 | **Pr / Pr** |
| | Acid | 5E-05 | 5E-06 | 0.0002 | 3E-05 | 2E-06 | 0.0001 | 2 | **Pr / Pr** |
| | TCP | 5E-06 | 2E-06 | 3E-05 | 3E-05 | 8E-06 | 0.0002 | 0.18 | **Pr / Pr** |
| To Southeast WWTP[4] | BEE | 4E-06 | 4E-08 | 2E-05 | 4E-05 | 5E-07 | 0.0003 | 0.091 | **Pr / Pr** |
| | Acid | 5E-06 | 5E-07 | 2E-05 | 3E-06 | 2E-07 | 9E-06 | 2 | **Pr / Pr** |
| | TCP | 5E-07 | 1E-07 | 3E-06 | 3E-06 | 8E-07 | 2E-05 | 0.18 | **Pr / Pr** |

BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.
DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable.
Hazard Quotients above 0.1 are shaded. HQs greater than one are bolded.

[1] Exposures for fish are not evaluated for Woodland Creek and puddle scenarios because there are no fish on Mount Sutro. The WWTP scenarios are not evaluated for amphibians because amphibians only live in fresh water.
[2] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
[3] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.
[4] Peak runoff to Oceanside and Southeast WWTPs was estimated using USFS/GLEAMS herbicide runoff rates and WWTP capacities. See Section 2.5.2.H for details.
[5] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[6] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all acres treated at an application rate of 1 lb/acre.
[7] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.

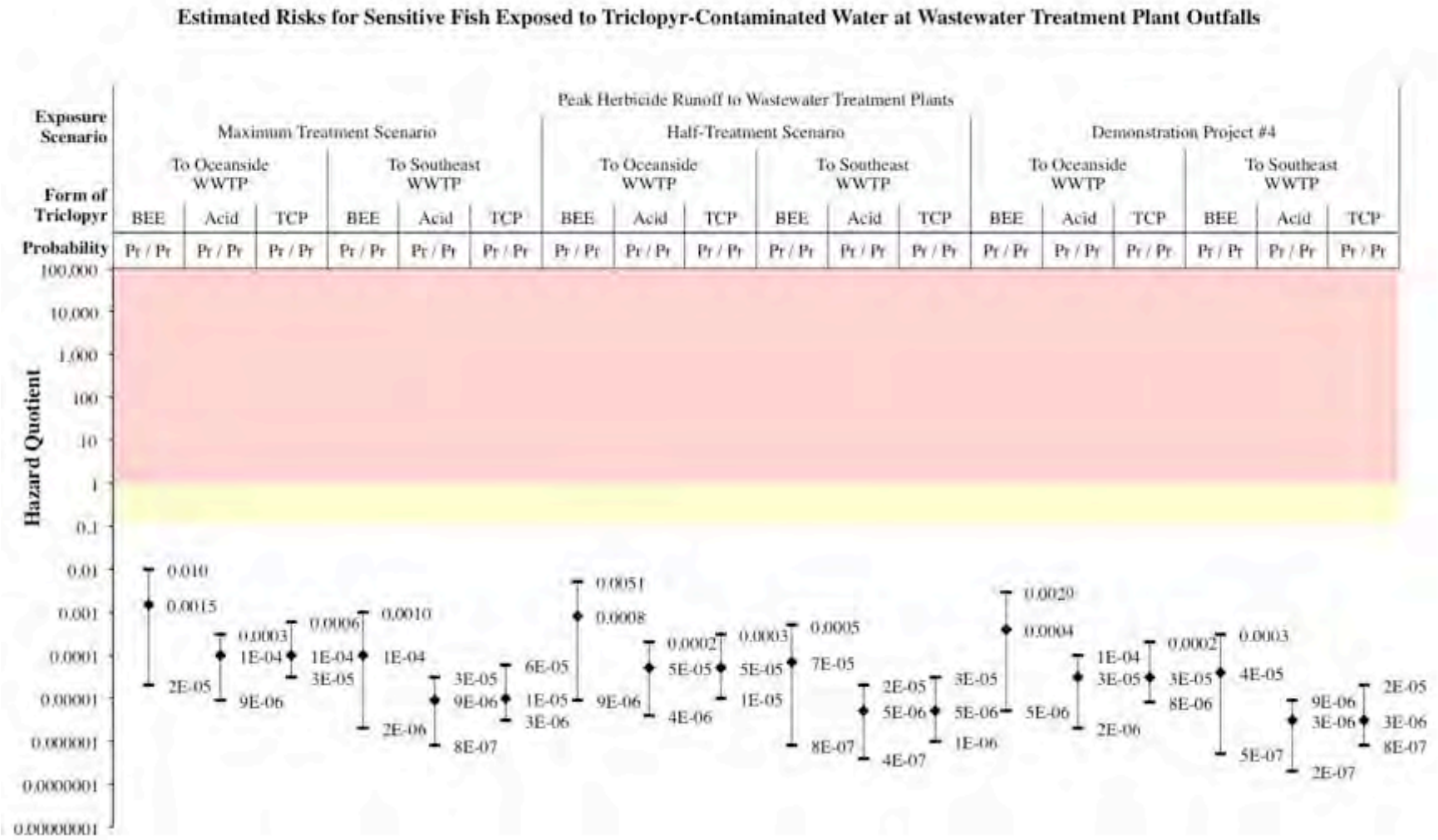



**Figure 4-16**: Estimated risks for sensitive species of fish exposed to triclopyr-contaminated water at the outfall zone of the wastewater treatment plants. See Table 4-27 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$.

**Table 4-28: Estimated Risks for Sensitive Aquatic Invertebrates Exposed to Triclopyr-Contaminated Water**

| Receptor | Scenario (or form of triclopyr[1]) | Concentration (mg/L) | | | Hazard Quotients | | | TRV (mg/L) | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| | | Central | Lower | Upper | Central | Lower | Upper | | |
| **Spills of Cut-Stump Solutions (5%, 20% or 50%)** | | | | | | | | | |
| Spill into puddle/pool | 1 gal | 7,255 | 907 | 181,377 | **161,224** | **20,153** | **4,030,604** | 0.045 | HI / HI |
| Spill into Woodland Creek | 1 gal | 427 | 53 | 2,667 | **9,484** | **1,185** | **59,274** | 0.045 | HI / HI |
| | 20 gal | 8,535 | 1,067 | 53,346 | **189,676** | **23,709** | **1,185,472** | 0.045 | HI / HI |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0016 | 6.00E-07 | 0.12 | 0.036 | 1E-05 | **2.7** | 0.045 | **Pr / Pr** |
| | Acid | 0.12 | 4.00E-06 | 0.96 | 0.0048 | 2E-07 | 0.04 | 25 | **Pr / Pr** |
| | TCP | 0.0036 | 4.00E-08 | 0.11 | 0.0065 | 7E-08 | 0.20 | 0.55 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0013 | 3.26E-11 | 0.24 | 0.000 | 1E-12 | 0.01 | 25 | **Pr / Pr** |
| | TCP | 7E-05 | 4.90E-13 | 0.008 | 0.000 | 1E-12 | 0.02 | 0.36 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0008 | 3.00E-07 | 0.06000 | 0.018 | 7E-06 | **1.3** | 0.045 | **Pr / Pr** |
| | Acid | 0.060 | 2.00E-06 | 0.48 | 0.0024 | 8E-08 | 0.02 | 25 | **Pr / Pr** |
| | TCP | 0.0018 | 2.00E-08 | 0.06 | 0.0033 | 4E-08 | 0.10 | 0.55 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0007 | 1.63E-11 | 0.12 | 0.000 | 7E-13 | 0.00 | 25 | **Pr / Pr** |
| | TCP | 0.00003 | 2.45E-13 | 0.004 | 0.000 | 7E-13 | 0.01 | 0.36 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0004 | 1.50E-07 | 0.03000 | 0.009 | 3E-06 | 0.67 | 0.045 | **Pr / Pr** |
| | Acid | 0.030 | 1.00E-06 | 0.24 | 0.0012 | 4E-08 | 0.01 | 25 | **Pr / Pr** |
| | TCP | 0.0009 | 1.00E-08 | 0.03 | 0.0016 | 2E-08 | 0.05 | 0.55 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0003 | 8.16E-12 | 0.06 | 0.000 | 3E-13 | 0.00 | 25 | **Pr / Pr** |
| | TCP | 0.00002 | 1.22E-13 | 0.002 | 0.000 | 3E-13 | 0.01 | 0.36 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0005 | 1.69E-07 | 0.03390 | 0.010 | 4E-06 | 0.75 | 0.045 | **Pr / Pr** |
| | Acid | 0.034 | 1.13E-06 | 0.271186441 | 0.0014 | 5E-08 | 0.01 | 25 | **Pr / Pr** |
| | TCP | 0.0010 | 1.13E-08 | 0.03164 | 0.0018 | 2E-08 | 0.06 | 0.55 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0004 | 9.22E-12 | 0.07 | 0.000 | 4E-13 | 0.00 | 25 | **Pr / Pr** |
| | TCP | 0.00002 | 1.38E-13 | 0.002 | 0.000 | 4E-13 | 0.01 | 0.36 | **Pr / Pr** |

| Receptor | Scenario (or form of triclopyr[1]) | Concentration (mg/L) Central | Lower | Upper | Hazard Quotients Central | Lower | Upper | TRV (mg/L) | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Herbicide Runoff to Wastewater Treatment Plants (5-year storm)** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| To Oceanside WWTP[8] | BEE | 0.0001 | 1.6E-06 | 9.2E-04 | 0.0031 | 3E-05 | 0.020 | 0.045 | **Pr / Pr** |
| | Acid | 0.0002 | 1.7E-05 | 7.0E-04 | 7.8E-06 | 7E-07 | 0.00 | 25 | **Pr / Pr** |
| | TCP | 0.00002 | 5.4E-06 | 1.2E-04 | 3.4E-05 | 1E-05 | 0.00 | 0.55 | **Pr / Pr** |
| To Southeast WWTP[8] | BEE | 0.00001 | 1.5E-07 | 8.7E-05 | 2.9E-04 | 3E-06 | 0.0019 | 0.045 | **Pr / Pr** |
| | Acid | 0.00002 | 1.6E-06 | 6.6E-05 | 7.3E-07 | 7E-08 | 0.0000 | 25 | **Pr / Pr** |
| | TCP | 0.000002 | 5.1E-07 | 1.1E-05 | 3.2E-06 | 9E-07 | 0.0000 | 0.55 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| To Oceanside WWTP[8] | BEE | 0.00007 | 7.8E-07 | 4.6E-04 | 1.5E-03 | 2E-05 | 0.0102 | 0.045 | **Pr / Pr** |
| | Acid | 0.00010 | 8.6E-06 | 3.5E-04 | 3.9E-06 | 3E-07 | 0.0000 | 25 | **Pr / Pr** |
| | TCP | 0.00001 | 2.7E-06 | 5.8E-05 | 1.7E-05 | 5E-06 | 0.0001 | 0.55 | **Pr / Pr** |
| To Southeast WWTP[8] | BEE | 0.00001 | 7.3E-08 | 4.3E-05 | 1.5E-04 | 2E-06 | 0.00097 | 0.045 | **Pr / Pr** |
| | Acid | 0.00001 | 8.2E-07 | 3.3E-05 | 3.7E-07 | 3E-08 | 0.00000 | 25 | **Pr / Pr** |
| | TCP | 0.00000 | 2.5E-07 | 5.5E-06 | 1.6E-06 | 5E-07 | 0.00001 | 0.55 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| To Oceanside WWTP[8] | BEE | 0.00003 | 3.9E-07 | 2.3E-04 | 7.7E-04 | 9E-06 | 0.00511 | 0.045 | **Pr / Pr** |
| | Acid | 0.00005 | 4.3E-06 | 1.7E-04 | 1.9E-06 | 2E-07 | 0.00001 | 25 | **Pr / Pr** |
| | TCP | 0.00000 | 1.3E-06 | 2.9E-05 | 8.4E-06 | 2E-06 | 0.00005 | 0.55 | **Pr / Pr** |
| To Southeast WWTP[8] | BEE | 0.000003 | 3.7E-08 | 2.2E-05 | 7.3E-05 | 8E-07 | 0.00048 | 0.045 | **Pr / Pr** |
| | Acid | 0.000005 | 4.1E-07 | 1.6E-05 | 1.8E-07 | 2E-08 | 0.00000 | 25 | **Pr / Pr** |
| | TCP | 0.000000 | 1.3E-07 | 2.8E-06 | 8.0E-07 | 2E-07 | 0.00001 | 0.55 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| To Oceanside WWTP[8] | BEE | 0.00004 | 0.0000004 | 0.00026 | 0.00087 | 1E-05 | 0.00577 | 0.045 | **Pr / Pr** |
| | Acid | 0.00005 | 0.0000049 | 0.00020 | 0.00000 | 2E-07 | 0.00001 | 25 | **Pr / Pr** |
| | TCP | 0.00001 | 0.0000015 | 0.00003 | 0.00001 | 3E-06 | 0.00006 | 0.55 | **Pr / Pr** |
| To Southeast WWTP[8] | BEE | 0.00000 | 0.0000000 | 0.00002 | 0.00008 | 9E-07 | 0.00055 | 0.045 | **Pr / Pr** |
| | Acid | 0.00001 | 0.0000005 | 0.00002 | 0.00000 | 2E-08 | 0.00000 | 25 | **Pr / Pr** |
| | TCP | 0.00000 | 0.0000001 | 0.00000 | 0.00000 | 3E-07 | 0.00001 | 0.55 | **Pr / Pr** |

TRV = Toxicity Reference Value; WWTP = Waste water treatment plant. Hazard Quotients above 0.1 are shaded. HQs greater than one are **bolded.**
DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable.
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.
[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.
[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.
[7] Peak runoff to Oceanside and Southeast WWTPs was estimated using USFS/GLEAMS herbicide runoff rates and WWTP capacities. See Section 2.5.2.H for details.

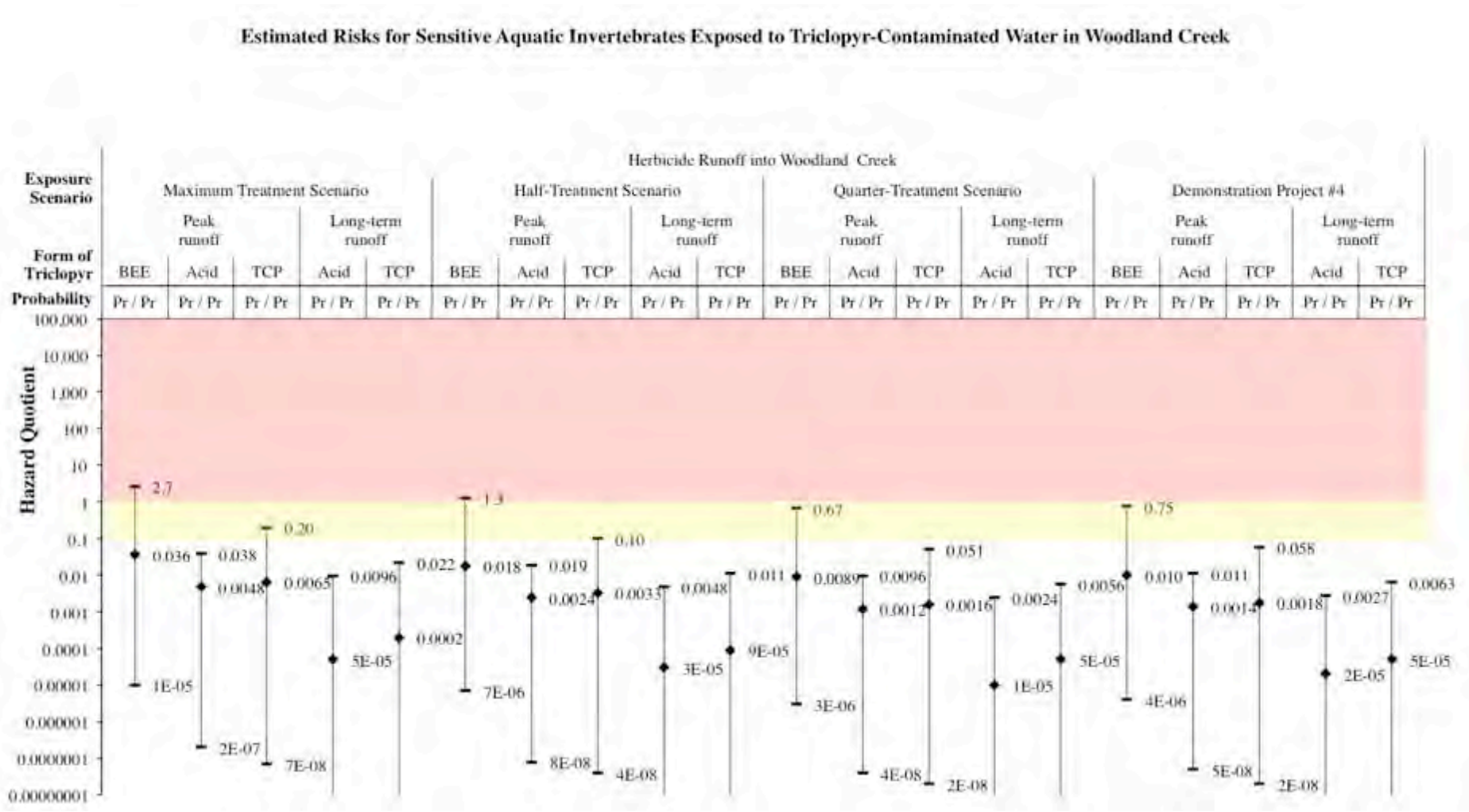



**Figure 4-17**: Estimated risks for sensitive species of aquatic invertebrates exposed to triclopyr-contaminated water in Woodland Creek. See Table 4-28 above for data used to create this chart and definitions of terminology and abbreviations used. Bars without numbers on the bottom have a Lower HQ less than $1x10^{-8}$.

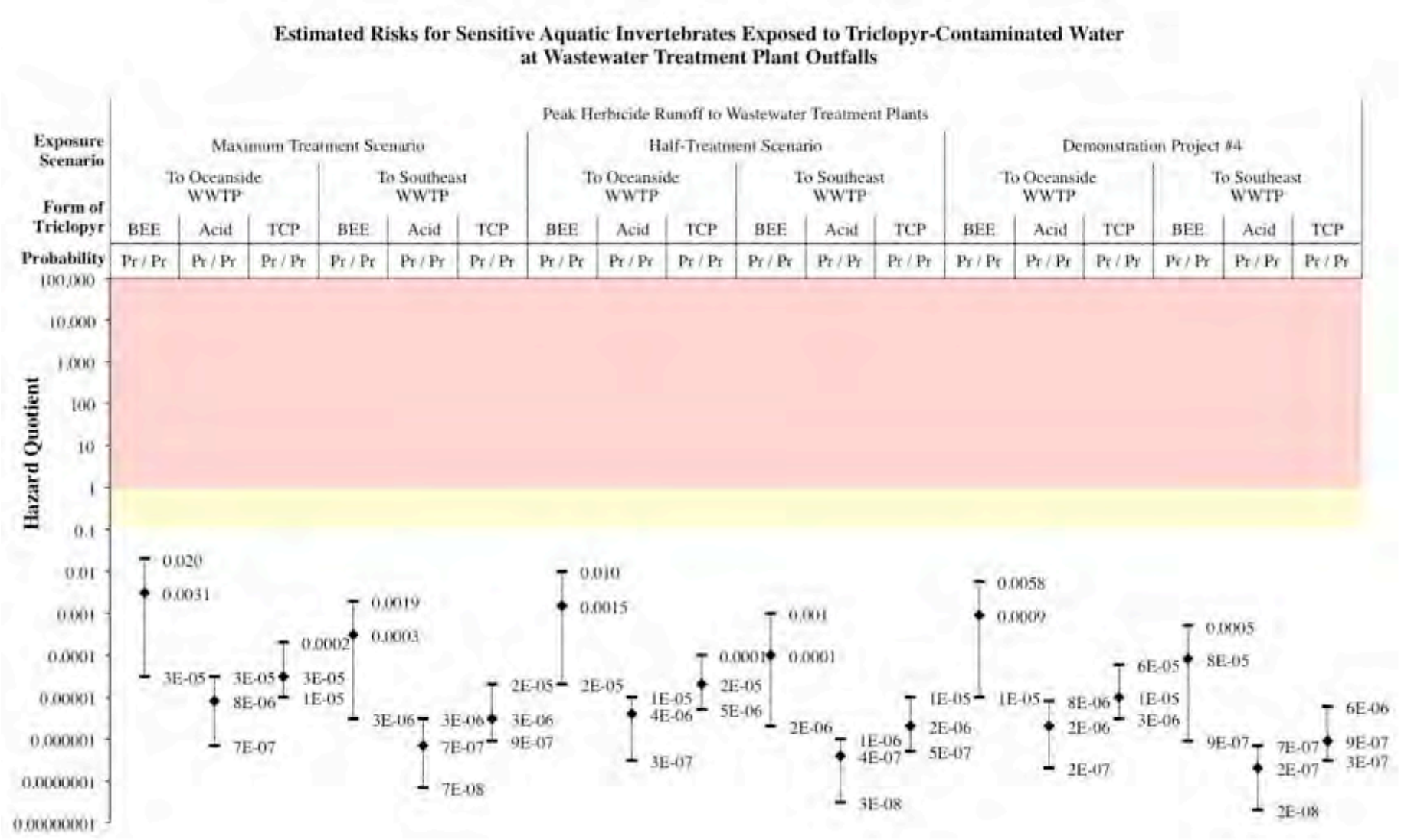



**Figure 4-18**: Estimated risks for sensitive species of aquatic invertebrates exposed to triclopyr-contaminated water at the outfall zone of the wastewater treatment plants. See Table 4-28 above for data used to create this chart and definitions of terminology and abbreviations used.

**Table 4-29: Estimated Risks for Aquatic Plants Exposed to Triclopyr-Contaminated Water**

| Scenario | Form of Triclopyr[1] | Concentration (mg/L) Central | Lower | Upper | Hazard Quotients Central | Lower | Upper | TRV (mg/L) | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Spills of Cut-Stump Solutions (5%, 20% or 50%)** | | | | | | | | | |
| Spill into puddle/pool | 1 gal | 7,255 | 907 | 181,377 | **5,182,206** | **647,776** | **129,555,143** | 0.0014 | HI / HI |
| Spill into Woodland Creek | 1 gal | 427 | 53 | 2,667 | **304,836** | **38,104** | **1,905,223** | 0.0014 | HI / HI |
| | 20 gal | 8,535 | 1,067 | 53,346 | **6,096,713** | **762,089** | **38,104,454** | 0.0014 | HI / HI |
| **Herbicide Runoff to Woodland Creek** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0016 | 6E-07 | 0.12 | **1.1** | 0.0004 | **86** | 0.0014 | **Pr / Pr** |
| | Acid | 0.12 | 4E-06 | 0.96 | 0.52 | 2E-05 | **4.2** | 0.23 | **Pr / Pr** |
| | TCP | 0.0036 | 4E-08 | 0.11 | 0.01 | 1E-07 | 0.31 | 0.36 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0013 | 3E-11 | 0.24 | 0.0058 | 1E-10 | **1.0** | 0.23 | **Pr / Pr** |
| | TCP | 7E-05 | 5E-13 | 0.0080 | 0.0002 | 1E-12 | 0.022 | 0.36 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0008 | 3E-07 | 0.060 | 0.57 | 0.0002 | **43** | 0.0014 | **Pr / Pr** |
| | Acid | 0.060 | 2E-06 | 0.48 | 0.26 | 9E-06 | **2.1** | 0.23 | **Pr / Pr** |
| | TCP | 0.0018 | 2E-08 | 0.056 | 0.0050 | 6E-08 | 0.16 | 0.36 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0007 | 2E-11 | 0.12 | 0.0029 | 7E-11 | 0.52 | 0.23 | **Pr / Pr** |
| | TCP | 3E-05 | 2E-13 | 0.0040 | 9E-05 | 7E-13 | 0.011 | 0.36 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0004 | 2E-07 | 0.030 | 0.29 | 0.0001 | **21** | 0.0014 | **Pr / Pr** |
| | Acid | 0.030 | 1E-06 | 0.24 | 0.13 | 4E-06 | **1.0** | 0.23 | **Pr / Pr** |
| | TCP | 0.0009 | 1E-08 | 0.028 | 0.0025 | 3E-08 | 0.078 | 0.36 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0003 | 8E-12 | 0.060 | 0.0015 | 4E-11 | 0.26 | 0.23 | **Pr / Pr** |
| | TCP | 2E-05 | 1E-13 | 0.0020 | 5E-05 | 3E-13 | 0.0056 | 0.36 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| Peak runoff[3] | BEE | 0.0005 | 2E-07 | 0.034 | 0.32 | 0.0001 | **24** | 0.0014 | **Pr / Pr** |
| | Acid | 0.034 | 1E-06 | 0.27 | 0.15 | 5E-06 | **1.2** | 0.23 | **Pr / Pr** |
| | TCP | 0.0010 | 1E-08 | 0.032 | 0.0028 | 3E-08 | 0.088 | 0.36 | **Pr / Pr** |
| Long-term runoff[3] | Acid | 0.0004 | 9E-12 | 0.068 | 0.0016 | 4E-11 | 0.29 | 0.23 | **Pr / Pr** |
| | TCP | 2E-05 | 1E-13 | 0.0023 | 5E-05 | 4E-13 | 0.0063 | 0.36 | **Pr / Pr** |

| Scenario | Form of Triclopyr[1] | Concentration (mg/L) Central | Lower | Upper | Hazard Quotients Central | Lower | Upper | TRV (mg/L) | Scenario Probability (DP / Proj) |
|---|---|---|---|---|---|---|---|---|---|
| **Herbicide Runoff to Wastewater Treatment Plants (5-year storm)** | | | | | | | | | |
| **Maximum Treatment Scenario[2]** | | | | | | | | | |
| To Oceanside WWTP[7] | BEE | 0.0001 | 2E-06 | 0.0009 | 0.099 | 0.0011 | 0.66 | 0.0014 | **Pr / Pr** |
| | Acid | 0.0002 | 2E-05 | 0.0007 | 0.0008 | 8E-05 | 0.0030 | 0.23 | **Pr / Pr** |
| | TCP | 2E-05 | 5E-06 | 0.0001 | 5E-05 | 1E-05 | 0.0003 | 0.36 | **Pr / Pr** |
| To Southeast WWTP[7] | BEE | 1E-05 | 1E-07 | 9E-05 | 0.0093 | 0.0001 | 0.062 | 0.0014 | **Pr / Pr** |
| | Acid | 2E-05 | 2E-06 | 7E-05 | 8E-05 | 7E-06 | 0.0003 | 0.23 | **Pr / Pr** |
| | TCP | 2E-06 | 5E-07 | 1E-05 | 5E-06 | 1E-06 | 3E-05 | 0.36 | **Pr / Pr** |
| **Half Treatment Scenario[4]** | | | | | | | | | |
| To Oceanside WWTP[7] | BEE | 7E-05 | 8E-07 | 0.0005 | 0.049 | 0.0006 | 0.33 | 0.0014 | **Pr / Pr** |
| | Acid | 1E-04 | 9E-06 | 0.0003 | 0.0004 | 4E-05 | 0.0015 | 0.23 | **Pr / Pr** |
| | TCP | 9E-06 | 3E-06 | 6E-05 | 3E-05 | 7E-06 | 0.0002 | 0.36 | **Pr / Pr** |
| To Southeast WWTP[7] | BEE | 7E-06 | 7E-08 | 4E-05 | 0.0047 | 5E-05 | 0.031 | 0.0014 | **Pr / Pr** |
| | Acid | 9E-06 | 8E-07 | 3E-05 | 4E-05 | 4E-06 | 0.0001 | 0.23 | **Pr / Pr** |
| | TCP | 9E-07 | 3E-07 | 6E-06 | 2E-06 | 7E-07 | 2E-05 | 0.36 | **Pr / Pr** |
| **Quarter Treatment Scenario[5]** | | | | | | | | | |
| To Oceanside WWTP[7] | BEE | 3E-05 | 4E-07 | 0.0002 | 0.025 | 0.0003 | 0.16 | 0.0014 | **Pr / Pr** |
| | Acid | 5E-05 | 4E-06 | 0.0002 | 0.0002 | 2E-05 | 0.0008 | 0.23 | **Pr / Pr** |
| | TCP | 5E-06 | 1E-06 | 3E-05 | 1E-05 | 4E-06 | 8E-05 | 0.36 | **Pr / Pr** |
| To Southeast WWTP[7] | BEE | 3E-06 | 4E-08 | 2E-05 | 0.0023 | 3E-05 | 0.016 | 0.0014 | **Pr / Pr** |
| | Acid | 5E-06 | 4E-07 | 2E-05 | 2E-05 | 2E-06 | 7E-05 | 0.23 | **Pr / Pr** |
| | TCP | 4E-07 | 1E-07 | 3E-06 | 1E-06 | 4E-07 | 8E-06 | 0.36 | **Pr / Pr** |
| **Demonstration Plot #4[6]** | | | | | | | | | |
| To Oceanside WWTP[7] | BEE | 4E-05 | 4E-07 | 0.0003 | 0.028 | 0.0003 | 0.19 | 0.0014 | **Pr / Pr** |
| | Acid | 5E-05 | 5E-06 | 0.0002 | 0.0002 | 2E-05 | 0.0009 | 0.23 | **Pr / Pr** |
| | TCP | 5E-06 | 2E-06 | 3E-05 | 1E-05 | 4E-06 | 9E-05 | 0.36 | **Pr / Pr** |
| To Southeast WWTP[7] | BEE | 4E-06 | 4E-08 | 2E-05 | 0.0026 | 3E-05 | 0.018 | 0.0014 | **Pr / Pr** |
| | Acid | 5E-06 | 5E-07 | 2E-05 | 2E-05 | 2E-06 | 8E-05 | 0.23 | **Pr / Pr** |
| | TCP | 5E-07 | 1E-07 | 3E-06 | 1E-06 | 4E-07 | 9E-06 | 0.36 | **Pr / Pr** |

TRV = Toxicity Reference Value; WWTP = Waste water treatment plant. Hazard Quotients above 0.1 are shaded. HQs greater than one are **bolded.**
DP = Demonstration Project, Proj = Main Project; HP = Highly Probable; Pr = Probable; Po = Possible; I = Improbable; HI = Highly Improbable
BEE = triclopyr butoxyethyl ester; Acid = triclopyr acid, degradation product of triclopyr BEE; TCP = 3,5,6-trichloro-2-pyridinol, degradation product of triclopyr acid.
[1] Triclopyr BEE is the active ingredient in Garlon 4 Ultra, the applied product. It degrades rapidly in the environment to produce triclopyr acid, which degrades more slowly to form TCP.
[2] The maximum treatment scenario is all acres treated at the maximum application rate of 4 lb a.e./acre.

[3] Peak and long-term runoff to Woodland Creek were estimated using the USFS method. See Section 2.5.2.F and 2.5.2.G for details.
[4] The half-treatment scenario is half the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 2 lb/acre.
[5] The quarter-treatment scenario is one-quarter of the acres treated at the maximum application rate of 4 lb a.e./acre or all of the acres treated at an application rate of 1 lb/acre.
[6] The Demonstration Project #4 scenario is two out of the 7.08 accessible acres in the Woodland Creek watershed treated at the maximum application rate of 4 lb a.e./acre.
[7] Peak runoff to Oceanside and Southeast WWTPs was estimated using USFS/GLEAMS herbicide runoff rates and WWTP capacities. See Section 2.5.2.H for details.

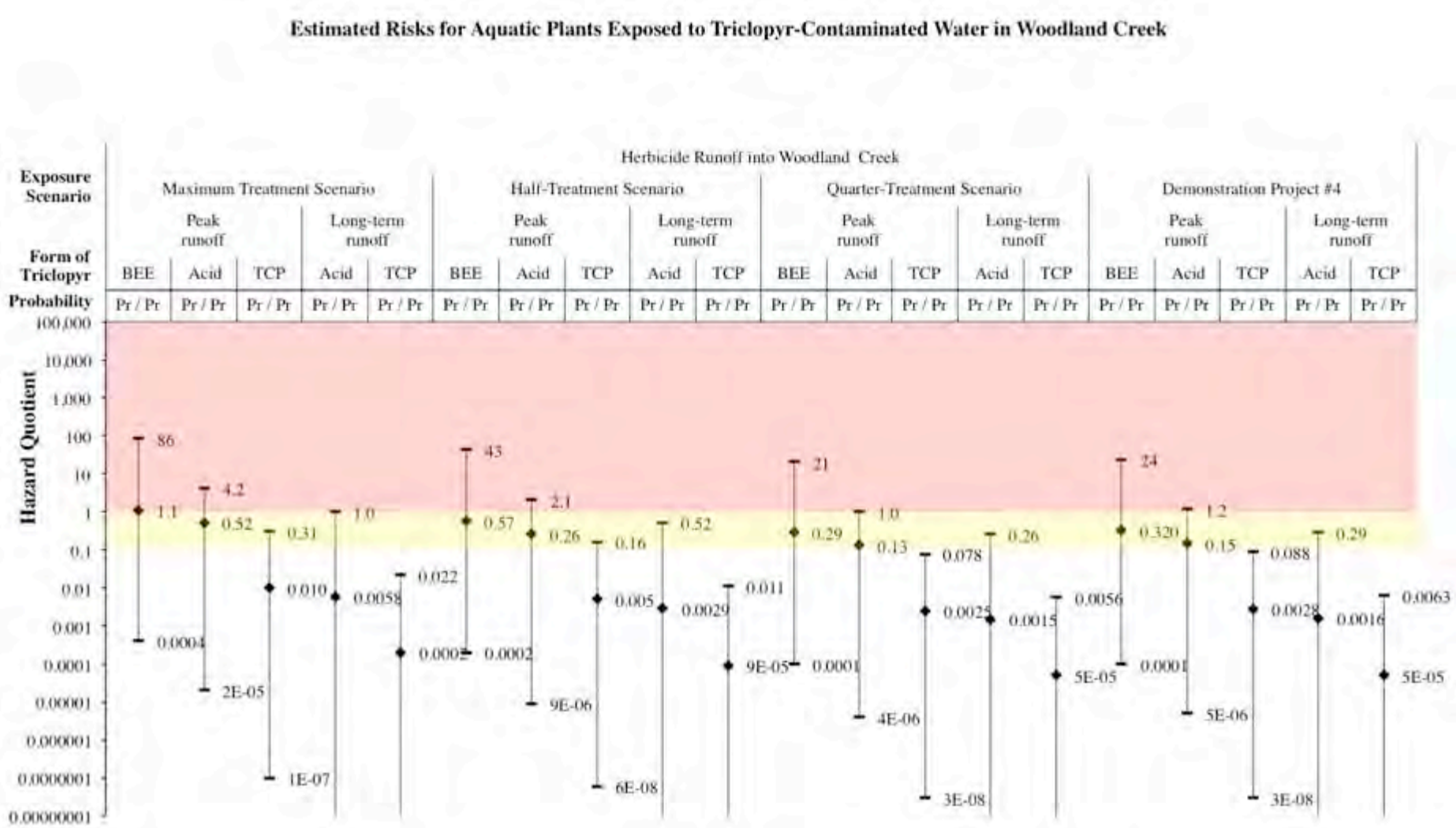



**Figure 4-19**: Estimated Risks for Aquatic Plants Exposed to Triclopyr-Contaminated Water in Woodland Creek. See Table 4-29 above for data used to create this chart and definitions of terminology and abbreviations used.

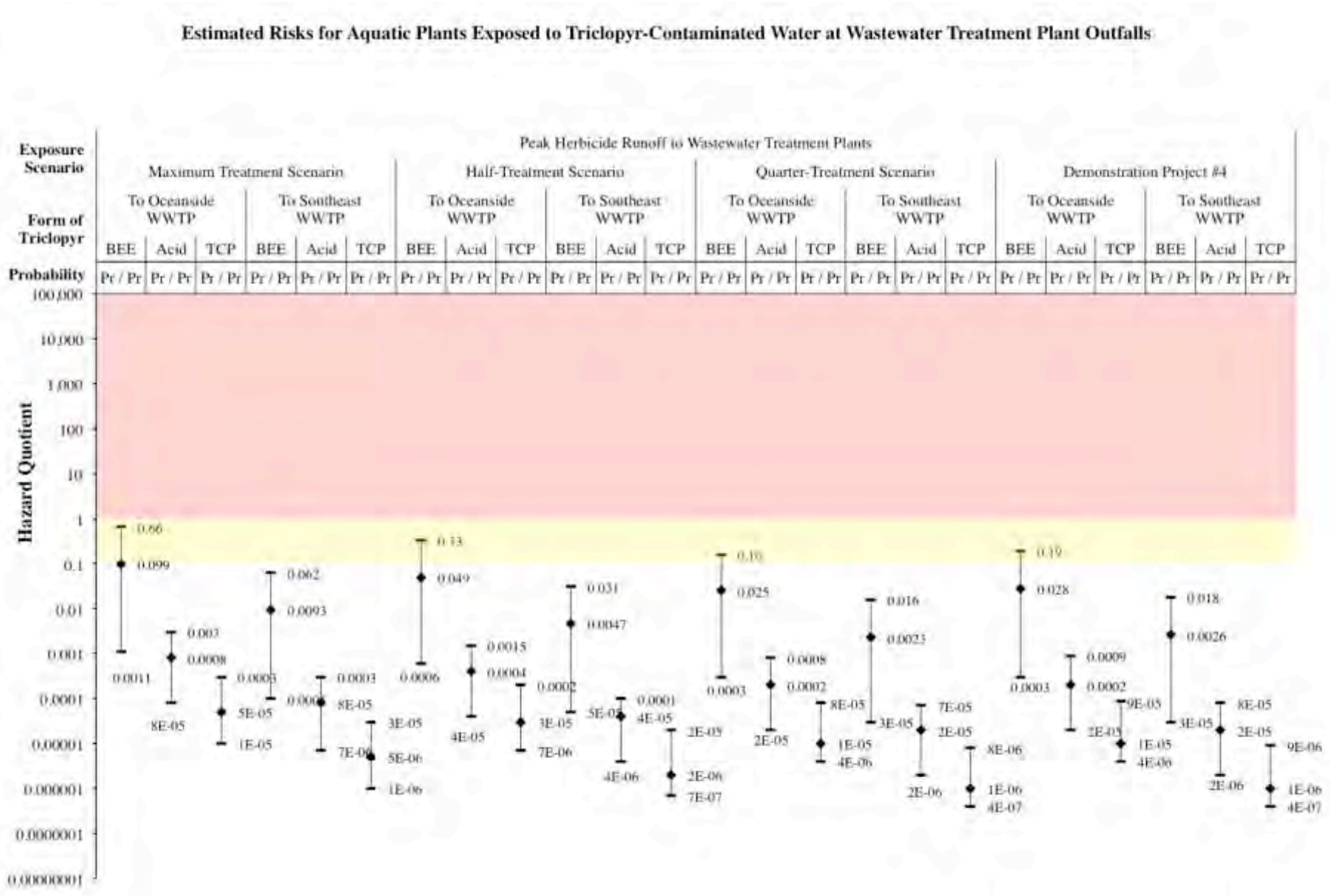



**Figure 4-20**: Estimated Risks for Aquatic Plants Exposed to Triclopyr-Contaminated Water at Wastewater Treatment Plant Outfalls. See Table 4-29 above for data used to create this chart and definitions of terminology and abbreviations used.

# References for Chapter 4

[1] US EPA. 2011. Grube A, Donaldson D, Kiely T, Wu L. *Pesticide Industry Sales and Usage 2006 and 2007 Market Estimates,* US Environmental Protection Agency. http://www.epa.gov/opp00001/pestsales/.

[2] CA Department of Pesticide Regulation, *California Pesticide Use Reporting Data,* http://www.cdpr.ca.gov/docs/pur/purmain.htm.

[3] CA Department of Pesticide Regulation. 2009. *Reports of Pesticide Sold in California.* http://www.cdpr.ca.gov/docs/mill/nopdsold.htm.

[4] EC. 2006. *Review Report for the Active Substance Triclopyr.* European Commission, Health & Consumer Protection Directorate-General, Directorate E.3—Chemicals, contaminants, pesticides. SANCO/10010/2006—rev.3. May 23, 2006. http://ec.europa.eu/sanco_pesticides/public/index.cfm?event=activesubstance.ViewReview&id=249.

[5] Burch, PL, WN Kline, RA Masters. Improved triclopyr formulations to control invasive weed and brush in forestry and industrial vegetation management programs. 2007 Proceedings. Symposia for Right of Way Vegetation Management in the South. Southern Weed Science Society, Volume 60. http://swss.omnibooksonline.com/data/papers/2007/2007_209.pdf.

[6] USFS. 2011. *Triclopyr Human Health and Ecological Risk Assessment Final Report.* 2011. Prepared for the US Forest Service by Syracuse Environmental Research Associates. http://www.fs.fed.us/foresthealth/pesticide/pdfs/052-25-03aTriclopyr.

[7] APAG. 1997. *The Safety of Fatty Acid Methyl Esters.* The European Oleochemicals and Allied Products Group. September 1997. http://www.apag.org/issues/methyl.htm

[8] Haller WT, Stocker RK. 2003. Toxicity of 19 adjuvants to juvenile *Lepomis macrochirus* (bluegill sunfish). *Env Toxic Chem* 22(3):615-619.

[9] Obribhabor BJ. 2007. Evaluation of the acute toxicity of refined petroleum products against *Pila ovata* (Gastropoda: Ampullariidae) and *Poecilia reticulata* (Teleostei: Poeciliidae). *African J Aqua Sci* 32(2):209-213.

[10] US EPA. 1998. *Triclopyr Re-registration Eligibility Decision (RED).* 1998. US Environmental Protection Agency. EPA-738-R-98-011. Washington, DC. http://www.epa.gov/oppsrrd1/REDs/2710red.pdf.

[11] US EPA. 2002. Triclopyr; Pesticide Tolerance Final Rule. *Fed Regis* 67(181): 58712-58725. Environmental Protection Agency 40 CFR Part 180 [OPP-2002-0190; FRL-7196-7]. September 18, 2002.

[12] US EPA. 2009. Risks of Triclopyr Use to Federally Threatened California Red-legged frog. US Environmental Protection Agency. http://www.epa.gov/espp/litstatus/effects/redleg-frog/#triclopyr.

[13] US EPA. *Ecotox database*. US Environmental Protection Agency. http://www.epa.gov/ecotox.

[14] US EPA 2002. Aggregate Risk Assessment for Trichloropyridinol (TCP) Metabolite of Triclopyr (PC Code 116001), Chlorpyrifos (PC Code 059101), and Chlorpyrifos-methyl (PC Code 059102). Memo from WH Donovan, WG Dykstra, and JT Swackhammer to J. Tompkins and J. Stone, June 6, 2002. Docket ID: EPA-HQ-OPP-2002-0190 at http://www.regulations.gov.

[15] Carmichael NG, Nolan RJ, Perkins JM, *et al.* 1989. Oral and dermal pharmacokinetics of triclopyr in human volunteers. *Hum Toxicol* 8(6): 431-437.

[16] Hotchkiss SA, Hewitt P, Caldwell J, *et al.* 1992. Percutaneous absorption of nicotinic acid, phenol, benzoic acid and triclopyr butoxyethyl ester through rat and human skin in vitro: further validation of an in vitro model by comparison with in vivo data. *Food Chem Toxicol* 30(10): 891-899.

[17] Zhang X, Acevedo S, Chao Y, Chen , Dinoff T, Driver J, Ross J, Williams R, Krieger R. 2011. Concurrent 2,4-D and triclopyr biomonitoring of backpack applicators, mixer/loader and field supervisor in forestry. *J Environ Sci Health B* 46(4):281-93.

[18] Gosselin NH, Brunet RC, Carrier G, *et al.* 2005. Worker exposures to triclopyr: risk assessment through measurements in urine samples. *Ann Occup Hyg* 49(5): 415-422.

[19] Spencer JR, Edmiston S, Cowan C, *et al.* 2000. Exposure of hand applicators to triclopyr in forest settings, 1995. California EPA, DPR, *Health and Safety Report HS-1769.* February 29, 2000. 47 pages.

[20] Abdelghani AA. 1995. *Assessment of the exposure of workers applying herbicide mixtures (2, 4-D+Roundup, Garlon-3a+Roundup): Toxicity and fate of these mixtures in the environment.* Report 90-6ss for the Louisiana Department of Transportation and Development.

[21] Middendorf, P. 1992b in USFS 2011, reference 6. *Forest worker exposures to triclopyr (3,5,6-trichloro-2-pyridinyloxyaceticacid), butoxyethyl ester during directed foliar applications of Garlon 4 herbicide.* Registrant study submitted by DowElanco. Produced by USDA Forest Service Federal Identifier #08-89-53-01 Project #A -841 6-000.

[22] Middendorf P, Timchalk C, Kropscott B *et al.* 1992 in USFS 2011, reference 6. Forest worker exposure to Garlon 4 herbicide. *Appl Occup Environ Hyg* 9: 589-594.

[23] CA DPR. *Pesticide Illness Surveillance Program.* California Department of Pesticide Regulation. http://www.cdpr.ca.gov/docs/whs/pisp.htm.

[24] US EPA. 2011. *Effects Determination for the California Red-legged Frog and Other California Listed Species.* See for example Appendix C for the glyphosate Effects Determination for a description of this process. http://www.epa.gov/espp/litstatus/effects/redleg-frog/#glyphosate

[25] Timchalk C, Dryzga MD, Kastl PE. 1990. Pharmacokinetics and metabolism of triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid) in Fischer 344 rats. *Toxicology* 62(1):71-87.

[26] Van Beeck L, Leegwater D. 1981a in USFS 2011, reference 6.

[27] Van Beeck L, Leegwater D. 1981 in EPA RED 1998, reference 10.

[28] Eckerlin RH, Ebel JG Jr, Maylin GA, *et al.* 1987. Excretion of triclopyr herbicide in the bovine. *Bull Env Contam Toxicol* 39(3):443-447.

[29] Timchalk C, Finco DR, Quast JF. 1997. Evaluation of renal function in rhesus monkeys and comparison to beagle dogs following oral administration of the organic acid triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid). Fund Appl Toxicol 36(1):47-53.

[30] Timchalk C, Nolan RJ. 1997. Pharmacokinetics of triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid) in the beagle dog and rhesus monkey: perspective on the reduced capacity of dogs to excrete this organic acid relative to the rat, monkey, and human. *Toxicol Appl Pharmacol* 144(2):268-278.

[31] US EPA. 1996. *Carcinogenicity peer review of triclopyr.* Memo from TF McMahon and E Rinde, Health Effects Div. to R Taylor, Registration Div. and T Luminello, Special Review and Reregistration Div. In Cox 2002, reference 66.

[32] Hanley TR Jr, Carney EW, Johnson EM. 2000. Developmental toxicity studies in rats and rabbits with 3,5,6-trichloro-2-pyridinol, the major metabolite of chlorpyrifos. *Toxicol Sci* 53(1):100-108.

[33] Wilbur-Ellis. MSDS for Competitor.

[34] Kuhn J. 2001 in USFS 2011, reference 6.

[35] Mizell M, Lomax L. 1989 in EPA RED 1998, reference 10.

[36] Henck JW, New MA, Johnson KA. 1979 in EPA RED 1998, reference 10.

[37] Olson KJ. 1967 in EPA RED 1998, reference 10.

[38] Gilbert K. 1996 in USFS 2011, reference 6.

[39] Kuhn J. 2000a in USFS 2011, reference 6.

[40] Nitschke K, Battjes J, Yano B. 1989 in EPA RED 1998, reference 10.

[41] Streeter C, Battjes J, Yano B. 1987 in EPA RED 1998, reference 10.

[42] Kuhn J. 2000d in USFS 2011, reference 6.

[43] Carreon R. 1985 in USFS 2011, reference 6.

[44] Mizell M. 1989 in USFS 2011, reference 6.

[45] Berdasco N. 1990a in USFS 2011, reference 6.

[46] Berdasco N. 1990b in USFS 2011, reference 6.

[47] Berdasco N. 1994b in USFS 2011, reference 6.

[48] Berdasco N. 1990c-d in USFS 2011, reference 6.

[49] Brooks K, DeWildt P. 2000 in USFS 2011, reference 6.

[50] Mizell M ; Lomax L. 1988 in EPA RED 1998, reference 10.

[51] Kuhn J. 2000b in USFS 2011, reference 6.

[52] Wall, J. 1987 in USFS 2011, reference 6.

[53] Sar TK, Bagchi B, Das SK, *et al.* 2002. Toxicokinetics, recovery, and metabolism of triclopyr butotyl (ACTP) ester in goats. JAgric Food Chem 50(15): 4202-4209.

[54] Finco D, Cooper T. 1995 in EPA RED 1998, reference 10.

[55] Lockwood D, Szabo J. 1992 in EPA RED 1998, reference 10.

[56] Goodman D, Hildebrandt P. 1996 in USFS 2011, reference 6.

[57] Cox C. 2000. Triclopyr Herbicide Factsheet. *J Pesticide Reform.* 20(4):12-19.

[58] USEPA. 1986. *Guidelines for Carcinogen Risk Assessment.* Risk Assessment Forum. EPA/630/R-00/004. Fed Regis 51(185):33992-34003. http://www.epa.gov/NCEA/raf/car2sab/guidelines_1986.pdf

[59] USEPA. 1999. *Draft Revised Guidelines for Carcinogen Risk Assessment.* July 1999. Office of Pesticides and Toxic Substances, Washington D.C. http://cfpub.epa.gov/ncea/raf/cancer.cfm.

[60] Landry T, Eisenstadt D, Gushow T. 1984 in EPA RED 1998, reference 10.

[61] Barna-Lloyd T, Yano B, Rachunek B. 1992 in USFS 2011, reference 6.

[62] Van Beeck L, *et al.* 1984 in USFS 2011, reference 6.

[63] Tsuda S, Ebino K, Ikeda M, *et al.* 1987 in USFS 2011, reference 6.

[64] Quast J, Gushow T, Stott W, *et al.* 1988 in USFS 2011, reference 6.

[65] Quast JF, Wade CE, Kalnins RV, *et al.* 1977 in USFS 2011, reference 6.

[66] Quast JF, Humiston CG;,LeBeau JE, *et al.* 1976 in USFS 2011, reference 6.

[67] Osweiler GD. 1983. Toxicology of triclopyr herbicide in the equine. Am Assoc Vet Lab Diagnost. 26th Ann Proc. pp. 193-201. In USFS 2011, reference 6.

[68] Eisenbrandt D, Firchau H, Wolfe E, *et al.* 1987. Eisenbrandt D. 1988. Response to: Memorandum. April 28, 1988 in USFS 2011, reference 6.

[69] Vedula U, Breslin W, Kropscott B, *et al.* 1995 in USFS 2011, reference 6.

[70] Beliles RP, Wosu NJ. 1976 in USFS 2011, reference 6.

[71] Hanley T, Thompson DJ, Palmer AK, *et al.* 1984. Teratology and reproduction studies with triclopyr in the rat and rabbit. *Fund Appl Toxicol* 4:872-882.

[72] Bryson A. 1994b in USFS 2011, reference 6.

[73] Breslin WJ; Billington R; Jones K. 1996. Evaluation of the developmental toxicity of triclopyr triethylamine salt (TTEA) and triclopyr butoxyethyl ester (TBEE) in rats. *Teratology*. 53(2):106.

[74] Thompson DJ, Dyke IL, Lower CE, *et al.* 1979 in USFS 2011, reference 6.

[75] Breslin W. 1990a in USFS 2011, reference 6.

[76] Carney EW, Billington R, Barlow SM. 2007. Developmental toxicity evaluation of triclopyr butoxyethyl ester and triclopyr triethylamine salt in the CD rat. *Reprod Toxicol* 23(2):165-74.

[77] Hanley T, Thompson D, Palmer A, *et al.* 1983 in USFS 2011, reference 6.

[78] Jones K. 1995 in USFS 2011, reference 6.

[79] Smith FA, Schwetz BA, Nitschke KD. *et al.* 1960 [sic] in USFS 2011, reference 6.

[80] Breslin WJ; Billington R. 1995 in USFS 2011, reference 6.

[81] Bryson A. 1994a in USFS 2011, reference 6.

[82] Bryson A. 1994c in USFS 2011, reference 6.

[83] Reddy TP, Manczak M, Calkins MJ, *et al.* 2011. Toxicity of neurons treated with herbicides and neuroprotection by mitochondria-targeted antioxidant SS31. *Int J Environ Res Public Health* 8(1):203-21.

[84] USDA Forest Service. 2002. Neurotoxicity, Immunotoxicity, and Endocrine Disruption with Specific Commentary on Glyphosate, Triclopyr, and Hexazinone: Final Report. Syracuse Environmental Research Associates, Inc. SERA TR 01-43-08-04a. February 14, 2002, p. 27.

[85] EC. 2000. Towards the establishment of a priority lists of substances for further evaluation of their role in endocrine disruption: Preparation of a candidate list of substances as a basis for priority setting. European Commission DG ENV. June 21, 2000. M0355008/1786Q. http://ec.europa.eu/environment/docum/01262_en.htm#bkh.

[86] PANNA. 2008. Clopyralid. *PesticideInfo Web Site.* Pesticide Action Network North America. http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC36359.

[87] Leslie *et al.* 1996 in USFS 2011, reference 6.

[88] (a) McMurry *et al.* 1993a,b in USFS 2011, reference 6.

(b) McMurry *et al.* 1994 in USFS 2011, reference 6.

[89] Beavers et. al. 1980 in USFS 2011, reference 6.

[90] a) Bovey and Meyer 1981 in USFS 2011, reference 6.

b) Coffman *et al.* 1993 in USFS 2011, reference 6.

c) Extoxnet 1996 in USFS 2011, reference 6.

d) Hatterman-Valenti *et al.* 1995 in USFS 2011, reference 6.

[91] Estok, D, B Freedman and D Boyle. 1989. Effects of the herbicides 2,4-D, glyphosate, hexazinone and triclopyr on the growth of three species of ectomycorrhizal fungi. *Bull Environ Contam Toxicol* 42: 835-839.

[92] Chakravarty, and Sidhu. 1987. Effects of glyphosate hexazinone and triclopyr on *in vitro* growth of five species of ectomycorrhizal fungi. *Europ J Forest Path* 17(4): 204-210.

[93] Ganapathy C. 1997. *Environmental Fate of Triclopyr.* CA Department of Pesticide Regulation, January 1997, and references contained therein. http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/triclopyr.pdf.

[94] Lee CH, Oloffs PC, Szeto SY. 1986 Persistence, degradation, and movement of triclopyr and its ethylene glycol butyl ether ester in a forest soil. *J Ag Food Chem* 34:1075–1079.

[95] Hoke, RA and GT Ankley. 2005. Application of frog embryo teratogenesis assay – *Xenopus* to ecological risk assessment. *Environ Tox Chem* 24(10): 2677-2690.

[96] Perkins, PJ, HJ Boermans, GR Stephenson. 2000. Toxicity of glyphosate and triclopyr using the frog embryo teratogenesis assay – *Xenopus*. *Environ Tox Chem* 19(4): 940-945.

[97] Berrill, M, S Bertram, L McGillivray, M Kolohon, B Pauli. Effects of low concentrations of forest-use pesticides on frog embryos and tadpoles. Environmental Toxicology and Chemistry 13(4): 657-664.

[98] Gersich *et al.*, 1984 in USFS 2011, reference 6.

[99] Ward T; Kowalski P, Boeri R. 1993 (MRID 42646101) in USFS 2011, reference 6.

[100] Ward T; Kowalski P, Boeri R. 1992 (MRID 42646102) in USFS 2011, reference 6.

[101] Heitmuller T. 1975 in USFS 2011, reference 6.

[102] Ward T, Boeri R. 1991e in USFS 2011, reference 6.

[103] Kreutzweiser DP, Holmes SB, Behmer DJ, 1992. Effects of the herbicides hexazinone and triclopyr ester on Aquatic insects. *Ecotoxicol Environ Safety* 23:364–374.

[104] Caceres T, He W, Naidu R, Megharaj M. 2007. Toxicity of chlorpyrifos and TCP alone and in combination to *Daphnia caranata*: The influence of microbial degradation in natural water. *Water Res* 41: 4497–4503.

[105] EC 2005. Review report for the active substance chlorpyrifos. European Commission Health & Consumer Protection Directorate-General. SANCO/3059/99-rev 1.5. June 3, 2005. http://ec.europa.eu/food/plant/protection/evaluation/existactive/list_chlorpyrifos.pdf.

[106] GS Siemering, JD Hayworth, BK Greenfield. Assessment of Potential Aquatic Herbicide Impacts to California Aquatic Ecosystems. *Arch Environ Contam Toxicol,* 2008. DOI 10.1007/s00244-008-9137-2

[107] Thompson DG *et al.*, in Ganapathy, reference 93.

[108] NMFS, 2008. *National Marine Fisheries Service Endangered Species Act Section 7 Consultation, Biological Opinion, Environmental Protection Agency Registration of Pesticides containing Chlorpyrifos, Diazinon, and Malathion.* November 18, 2008.

[109] HSDB. 2003. National Library of Medicine, TOXNET. *Triclopyr*. Hazardous Substances Data Bank. Revised Sept. 2003. http://toxnet.nlm.nih.gov.

[110] USDA. 2008. *Triclopyr.* Agricultural Research Service Pesticide List. http://www.ars.usda.gov/Services/docs.htm?docid=14147.

[111] Woodburn and Cranor, Aerobicaquatic metabolism of [$^{14}$C] triclopyr, GH-C 1987, Dow AgroSciences, Indianapolis, IN USA (1987), as cited in Petty DG *et al.*, *The aquatic fate of triclopyr in whole pond treatments*, Pest Manag Sci 57:764-775. http://www3.interscience.wiley.com/journal/85006609/abstract?CRETRY=1&SRETRY=0.

[112] Laskowski and Bidlack, *Anaerobic degradation of triclopyrbutoxyethyl ester*, GH-C 2093Dow AgroSciences, Indianapolis, IN (1984), as cited in Petty DG et al., The aquatic fate of triclopyr in whole pond treatments, *Pest Manag Sci* 57:764-775. http://www3.interscience.wiley.com/journal/85006609/abstract?CRETRY=1&SRETRY=0.

[113] Linders, *et al.*, 1984. in Ganapathy, reference 93.

[114] Woodburn, Hugo, *et al.* 1993b in Ganapathy, reference 93.

[115] Woodburn *et al.*, 1993a in Ganapathy, reference 93.

[116] CA DPR. California Department of Pesticide Regulation Pesticide Physical Properties Database. Personal communication with John Troiano.

[117] Petty DG *et al.* 2001. The aquatic fate of triclopyr in whole pond treatments, *Pest Manag Sci* 57: 764-775.

[118] USDA, Forest Service. 1984, in Ganapathy, reference 93.

[119] Bidlack, 1978 in Ganapathy, reference 93.

[120] Kollman and Segawa 1995, in Ganapathy, reference 93.

[121] Wilcock, Costley, *et al.* 1991, in Ganapathy, reference 93.

[122] Cryer, *et al.* 1993, in Ganapathy, reference 93.

[123] Plaumann, Mackasey and Oostenbrink.1983a in Ganapathy, reference 93.

[124] Newton, Roberts, *et al.*, 1990 in reference in Ganapathy, reference 93.

[125] Plaumann et al.,1983 in Ganapathy, reference 93.

[126] Personal communication with Bob Brenton, Brenton VMS.

[127] T. Barry and J. Walters, *Characterization of Propanil Prune Foliage Residues as Related to Propanil Use Patterns in the Sacramento Valley, California,* California Department of Pesticide Regulation, Report #EH 02-04, October 2002, http://www.cdpr.ca.gov/docs/empm/pubs/ehapreps.htm.

[128] Butler *et al.*, 1993 in Ganapathy, reference 93.

[129] Lee *et al.* 1986 in Ganapathy, reference 93.

[130] Stephenson *et al.*, 1990 in Ganapathy, reference 93.

[131] Linders et al., 1994 in Ganapathy, reference 93.

[132] Hamaker, 1974 in Ganapathy, reference 93.

[133] JN Smith, RC Martin, RG Croix, Levels of the herbicide glyphosate in well water. *Bull Envi Contam Toxicol* 1996. 57:759–65. http://www.springerlink.com/content/cmncreempr5l4pdf/?p=7e8cf8e87fd34615bdfc1af39b78c4fc&pi=0.

[134] Kjaer J, Ullum M, Olsen P, *et al. The Danish Pesticide Leaching Assessment Programme: Monitoring Results May 1999–June 2002. Third Report.* 2003. Geological Survey of Denmark and Greenland. Danish Institute of Agricultural Sciences, National Environmental Research Institute, Denmark.

[135] US EPA. 2004. *Analysis of risks to endangered and threatened salmon and steelhead.* US Environmental Protection Agency. December 1, 2004. http://www.epa.gov/espp//litstatus/effects/triclopyr/analysis.pdf.

[136] Bovey RW, *et al.* in Ganapathy, reference 93.

[137] Whisnant SG, McArthur ED. 1989 in Ganapathy, reference 93.

[138] a) Dow Elanco data package 51566-006, Garlon 3A studies, in Ganapathy, reference 93.

b) Dow Elanco data package 51566-006, Garlon 4 studies, in Ganapathy, reference 93.

[139] S.A. Cryer et al. 1993 in Ganapathy, reference 93.

[140] M. Newton et al. (1990) in Ganapathy, reference 93.

[141] B.J. Wilcox *et al.* (1991) in Ganapathy, reference 93.

[142] Holmes KA, Berry AM. 2009. Evaluation of off-target effects due to basal bark treatment for control of invasive fig trees (Ficus carica). *Invasive Plant Science and Management* 2:345–351.

[143] Bakke D, 2001. A review and assessment of the results of water monitoring for herbicide residues for the years 1991 to 1999: USFS Region Five. Proceedings - Forest Vegetation Management Conference (22nd): 42-65. Obtained from D. Bakke.

[144] Fox AM, Haller WT, Getsinger KD, *et al.* 2002. Dissipation of triclopyr herbicide applied in Lake Minnetonka, MN concurrently with Rhodamine WT dye. *Pest Manag Sci* 58: 677–686.

[145] Battaglin WA, Rice KC, Focazio MJ, Salmons S, Barry RX. 2009. The occurrence of glyphosate, atrazine,and other pesticides in vernal pools and adjacent streams in Washington, DC, Maryland, Iowa, and Wyoming, 2005–2006. *Environ Monit Assess* 155:281–307 DOI 10.1007/s10661-008-0435-y.

[146] Dow AgroSciences. Garlon 4 Ultra MSDS. http://www.cdms.net/LDat/mp7IN005.pdf.

[147] Dow AgroSciences. Garlon 4 Ultra Label. http://www.cdms.net/LDat/ld7IN006.pdf.

[148] US EPA rates acute product hazards on a scale of I to IV, with I the most-toxic and IV the least-toxic category.

[149] Labeling requirements for Pesticides and Devices. Code of Federal Regulations, Title 40, Vol. 16, Part 156. http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi?TITLE=40&PART=156&SECTION=10&YEAR=2000&TYPE=TEXT.

[150] UCSF Campus Planning. 2010. Notice of Preparation / Initial Study: University of California San Francisco Mount Sutro Management. http://campusplanning.ucsf.edu/pdf/Initial_Study_UCSF_Mt_Sutro_Mgmt.pdf.

[151] USFS. 2010. Triclopyr Risk Assessment Worksheets. http://www.fs.fed.us/foresthealth/pesticide/worksheets.shtml.

[152] SERA. 2007. Preparation of Environmental Documentation and Risk Assessments for the USDA/Forest Service. Syracuse Environmental Research Associates, Inc. January 21, 2007, Fayetteville, NY. http://www.sera-inc.com/images/SERA_MD_2007-01a_Risk_Assessment_Methods_for_Forest_Service.pdf.

USFS. 2004. *Clopyralid Human Health and Ecological Risk Assessment Final Report.* 2004. Prepared for the US Forest Service by Syracuse Environmental Research Associates, Inc. Report No. SERA TR 04-43-17-03c. December 4, 2004. http://www.fs.fed.us/foresthealth/pesticide/risk.shtml.

[153] Carmichael 1989 in USFS 2011, reference 6.

[154] (a) Middendorf 1992 in USFS 2011, reference 6.

(b) Middendorf et al. 1992 in USFS 2011, reference 6.

(c) Spencer 2000 in USFS 2011, reference 6.

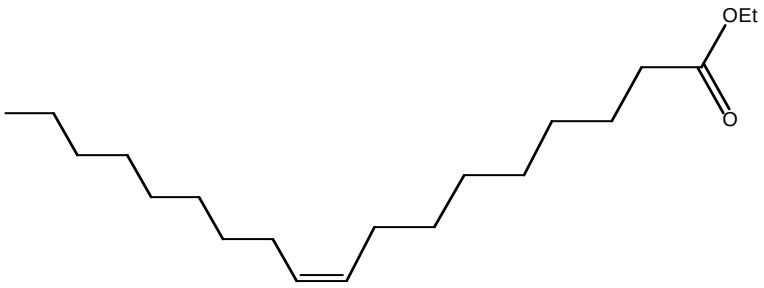
[155] (a) Kreutzweiser, DP et al. 1995. Field evaluation of triclopyr ester toxicity to fish. *Archives of Contamination and Toxicology*. 28(1):18-26.
(b) Norris, LA, ML Montgomery LE Warren. 1987. Triclopyr persistence in western Oregon hill pastures. *Bulletin of Environmental Contamination and Toxicology* 39(1): 134-1441
(c) Smith, CT and ML McCormack. 1988. Watershed losses of triclopyr after aerial application to release spruce-fir. *Proc Ann Meet Northeast Weed Sci.* 42:104-108.
(d) Thompson, DG, Staznik, Fontaine, DD. *et al.* 1991. Fate of triclopyr ester (Release) in a boreal forest stream. *Environ Toxicol Chem* 10(5): 619-632.
(e) Thompson, DG, DP Kreutzweiser, Capell SS et al. 1995. Fate and effects of triclopyr ester in a first-order forest stream. *Environ Toxicol Chem* (14(8): 1307-1317.

[156] UCSF. 2001. *Mount Sutro Open Space Reserve Management Plan, September 2001.* University of California, San Francisco. September 2001.campusplanning.ucsf.edu/pdf/Mount_Sutro_Reserve_Plan.pdf.

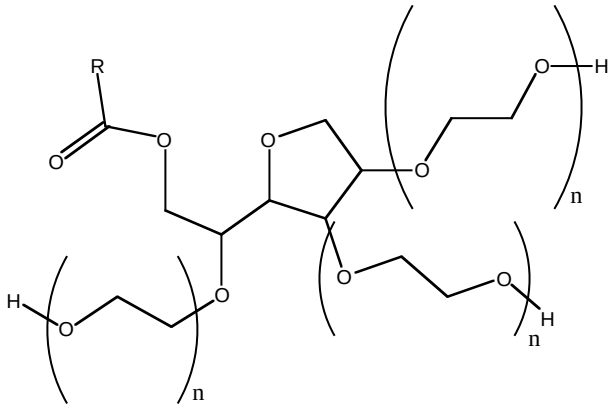
[157] USFS. 2011. Appendices to *Triclopyr Human Health and Ecological Risk Assessment Final Report* (SERA TR-052-25-03a-App), Appendices. http://www.fs.fed.us/foresthealth/pesticide/pdfs/Triclopyr_SERA_TR-052-25-03a-App.pdf.

[158] LSA Associates, Inc. 2011. Biological Resources Report: Mount Sutro Open Space Reserve ( No. LSA Project No. USF1001).

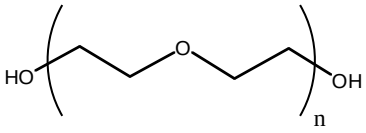
# Chapter 5—Surfactants and Dyes



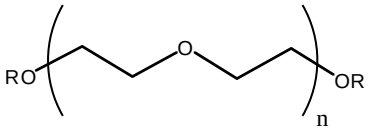

Ethyl oleate




Sorbitan alkylpolyethoxylate




Polyethylene glycol (PEG)




Dialkyl polyethylene glycol
R = alkyl group

# 5 Table of Contents — Surfactants and Dyes

**5.1 INTRODUCTION ..... 5-3**
**5.2 COMPETITOR COMPOSITION AND BACKGROUND INFORMATION ..... 5-4**
**5.3 COMPETITOR TOXICITY TO MAMMALS ..... 5-6**
**5.4 COMPETITOR TOXICITY TO INSECTS AND AQUATIC ORGANISMS ..... 5-7**
**5.5 ISSUES RELATED TO HERBICIDE USE WITH SURFACTANTS ..... 5-10**
**5.6 BLAZON BLUE DYE TOXICITY ..... 5-12**
**5.7 ENVIRONMENTAL FATE AND TRANSPORT ..... 5-12**
**REFERENCES FOR CHAPTER 5 ..... 5-13**

## Table of Tables

Table 5-1: Comparison of the Aquatic Toxicity of Various Surfactants ..... 5-9

## 5.1 Introduction

One surfactant—Competitor—and one dye—Blazon Blue dye—are being considered for use in the Mount Sutro project. Surfactants are materials added to active herbicidal ingredients to improve performance. Surfactants facilitate herbicidal activity by improving herbicide dispersal, absorption, spread, adherence and/or penetration to foliage or cut stumps/stems. Water droplets containing a surfactant will spread in a thin layer over a waxy leaf surface and penetrate the waxy leaf cuticle more easily. Surfactants also facilitate absorbtion of less water-soluble herbicides into cut-stumps/stems and are used to control spray drift by altering the surface tension of the solution so small droplets cannot form.

The purpose of the dye is to mark areas that have been treated with herbicides to ensure full coverage and avoid duplicative treatments. The dye also serves to notify workers and the general public of the location of treated areas.

The EPA does not register surfactants or dyes, nor does the Agency review their labels. No toxicity information is required to be submitted for the individual ingredients in surfactant mixtures or for the mixtures themselves. However, EPA has categorized approximately 1,200 "inert" ingredients into four lists, and some of the surfactant ingredients are on these lists.[1] Lists 1 and 2 contain inert ingredients of toxicological concern. List 4 contains nontoxic substances such as vegetable oils and water. List 3 includes substances for which the EPA has insufficient information to classify as either hazardous (Lists 1 and 2) or nontoxic (List 4). This chapter also provides information on the EPA inerts list for the known surfactant ingredients, where this information is available.

In 2006 after most of the pesticide re-registrations were complete, EPA dropped this listing scheme for "inert" ingredients, although other organizations continue to use the classifications, as noted by EPA.[1]

> ***"Note**: The List Category policy, created in 1987, has now served its purpose as a tool for prioritizing the evaluation of chemicals. Now that reassessment of food tolerances/tolerance exemptions under the Food Quality Protection Act (FQPA) is complete, there are no longer inerts classified as List 1, 2, or 3. All-food use inert ingredient tolerances and tolerance exemptions are considered to be safe when used according to the conditions set forth in the CFR's text and tables. As noted above, the "4A" category is still being used for the purposes of FIFRA Section 25(b), and USDA is still utilizing "List 4" for their National Organic Program. For non-food inert ingredients, the 1987 List Category policy remains pertinent (including labeling) for those identified as "List 1" (toxicological concern). For informational purposes you can still access EPA's old inert list categories."*

Risk assessments can only be conducted for chemicals for which toxicity data and physical properties that describe the persistence and mobility of the chemical are available. For the Mount Sutro project, sufficient data were not available to conduct a risk assessment for the surfactant Competitor and Blazon dye. The available toxicity and environmental fate data are summarized in this chapter.

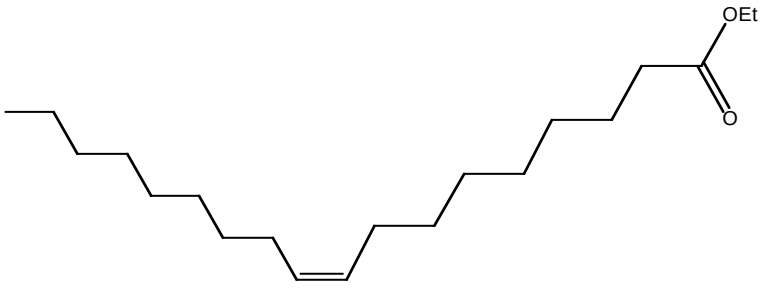
Information on the surfactants and dye were obtained from several sources, including the labels and MSDSs, the Loveland Products web site,[2] the USFS documents on surfactants,[3] a risk assessment developed for the San Francisco cordgrass project[4] and the USFS Plumas County risk assessment.[5] Additional work from the National Toxicology Program and the peer-reviewed literature is also included and is discussed below.

## *5.2 Competitor Composition and Background Information*

Surfactants are typically mixtures of ingredients, some of them polymers of varying chain length, and are difficult to characterize and analyze in the environment. In this section, the known ingredients in Competitor are described. The actual percentages of each component are not precisely known because the formulation is proprietary.

Competitor is a nonionic surfactant, with 98% of the product comprised of a mixture of the ethyl ester of oleic acid (ethyl oleate, CAS number 111-62-6), sorbitan alkylpolyethoxylate, and dialkyl polyoxyethylene glycol (PEG).[6] Competitor was designed specifically for use in water and contains a low-toxicity alkyl ethoxylate instead of nonyl phenol ethoxylate (NPE), which is associated with endocrine disrupting effects in aquatic ecosystems.[3, 7]

**Ethyl oleate:** Ethyl oleate is a fatty acid ester prepared by reacting oleic acid derived from seed oils (*e.g.* corn, soybean, sunflower, canola) with ethanol (the same alcohol in beer, wine and liquor).




Ethyl oleate

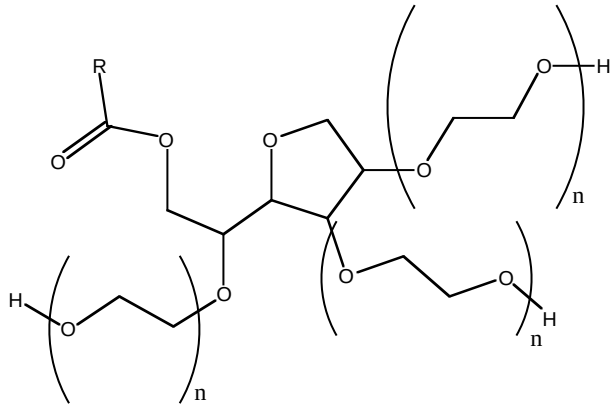
Ethyl oleate is both metabolized and synthesized by the human body. Metabolism of ethyl oleate occurs rapidly to produce ethanol and oleic acid, with a half-life in rats of less than 24 hours.[8] Both ethanol and oleic acid are metabolized further to produce energy for the organism, just as if the two separate ingredients had been ingested in the diet. In the presence of high concentrations of ethanol in the body, e.g., when alcohol is consumed, enzymes in the mammalian system produce ethyl oleate.[8]

The FDA has approved the use of ethyl oleate as a food additive.[9] The methyl, ethyl, propyl and butyl esters of oleic acid are used as emollients in cosmetics and other personal care products and as lubricants.[10]

**Sorbitan alkylpolyethoxylate:** The class of chemicals known as the alcohol ethoxylates (AEs) are among the highest production volume chemicals in the US. These nonionic surfactants are used in detergents and other household products, in foods and pharmaceuticals as emulsifiers,

and in lubricants.[11, 12] They are ubiquitous in the environment due to their discharge through wastewater treatment systems, but are readily degraded by microbes.

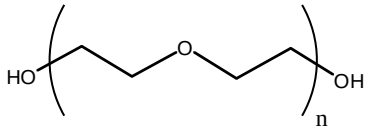
Sorbitan alkylpolyethoxylate is a nonionic surfactant prepared by reacting sorbitol, a sugar occurring naturally in fruits, with a carboxylic acid (often a fatty acid) and ethylene oxide. The type of carboxylic acid and the number of moles of ethylene oxide in the surfactant alters the properties of the surfactant. The identity of the carboxylic acid bound to sorbitol in Competitor is not specified.



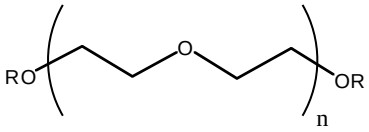

Sorbitan alkylpolyethoxylate

The "Tween" and "Polysorbate" family of surfactants are representative members of the sorbitan alkylpolyethoxylate class of surfactants, and some of these compounds are used in foods, injectable and ingestible drugs, and personal care products.[13] The FDA has approved the use of several of the polysorbates as food additives.[9]

**Dialkyl polyoxyethylene glycol (PEG):** Polyethylene glycol is a polymer synthesized by reaction of glycol with varying amounts of ethylene oxide. The terminal hydroxyl groups can be alkylated to produce various dialkyl PEG compounds.




Polyethylene glycol (PEG)




Dialkyl polyethylene glycol
R = alkyl group

PEG is widely used in cosmetics, toothpastes, and drugs such as laxatives.[14] Fruitjia- Pölloth summarizes the uses of PEG and PEG derivatives.[14a]

> *"Polyethylene glycols (PEGs) and their anionic or nonionic derivatives are widely used in cosmetics as surfactants, cleansing agents, emulsifiers, skin conditioners, and humectants. . . . Further to their use in cosmetics, many of the compounds have other applications. . . . In the pharmaceutical industry, for instance, they are used as vehicles for drugs and as ointment bases, capsules, tablet and pill binders, suppositories, liquid prescriptions, and in veterinary drugs, including parenteral, topical, ophthalmical, oral,*

*and rectal preparations. Further applications include use as ingredients in soaps and detergents, in the textile and leather industry, in plastics and resins, in the paper industry, in printing, in the ceramics and glass industry, in the rubber, petroleum, mining and metal industries, for wood preservation and as chemical intermediates. Polyoxyethylene sorbitan esters (polysorbates) and polyethylene glycol with an average molecular weight of 6000 are permitted as food additives in various foods according to the European Parliament and Council Directive No. 95/2/EC of 20 February 1995. The WHO has set an estimated acceptable daily intake of polyethylene glycols at up to 10 mg/kg bw."*

## 5.3 Competitor Toxicity to Mammals

The acute toxicity of surfactants to mammals and birds is generally low, and these substances are widely used in personal care products, cosmetics, drugs (including drugs that are directly injected) and in some cases, in foods. Little is known about the chronic or reproductive toxicity of most surfactants. Every substance is different however, and the physical properties and toxicity will vary depending on the specific functionality of each surfactant.

Competitor is not acutely toxic to humans and terrestrial wildlife. The chronic toxicity of the mixture remains unknown, although additional information is available on some of the components of the mixture, discussed below. There is no information on the toxicity of the mixture of this surfactant with Aquamaster, Garlon 4 Ultra, or Transline.

**Product mixture:** The only information available on the toxicity of the mixture of ingredients sold as Competitor is on the label[6] or MSDS.[15] The oral $LD_{50}$ for rats and the dermal $LD_{50}$ for rabbits exposed to Competitor are both greater than 5,000 mg/kg. Competitor has a "Caution" signal word on the label, meaning that it has low acute toxicity. It is minimally irritating to the eyes and is not toxic or irritating to the skin.[15] There is no information available on chronic toxicity, including cancer, endocrine disruption, or reproductive and developmental toxicity.

**Ethyl oleate:** Ethyl oleate is a List 4 minimal risk "inert" and is considered to be non-toxic. It is approved for use in foods by the FDA.[9] The Environmental Working Group (EWG) Skin Deep Cosmetics database gives ethyl oleate a very low hazard ranking of 0 on a scale of 0–10.[16] This compound is readily metabolized through well-known metabolic pathways and is not anticipated to be toxic to humans or animals at levels that may result from use with herbicides on Mount Sutro.

**Sorbitan alkylpolyethyoxylate:** Depending on the side chain, sorbitan alkylpolyethyoxylates are rated as either List 3 (unknown toxicity) or List 4 minimal risk "inerts." The monooleic, monolauric, monostearic and tristearic acid derivatives of polysorbate are approved for use in foods by the FDA,[9] and the same set of sorbate esters has been approved by EPA for exemptions from tolerances on foods.[17] The EWG Skin Deep Cosmetics database gives sorbitan alkyl ethoxylates a low to high hazard ranking of 0–9 on a scale of 0–10, depending on the side chain in the molecule. The studies that back up these rankings are not directly cited on the web site.

The National Toxicology Program has reviewed polyoxyethylene sorbitan monooleate (CAS number 9005-65-6) for developmental toxicity.[18] Rats were dosed at levels of 0, 500 or

5,000 mg/kg-day on gestation days 6–15, and the animals were evaluated for maternal and fetal toxicity effects. The data indicate a maternal LOAEL of 500 mg/kg-day based upon an increase in maternal relative liver weight at this dose. No definitive adverse effects on prenatal development were noted in this study, and the developmental NOAEL was deemed to be greater than 5,000 mg/kg/day.

The toxicity of the sorbitan alkylpolyethoxylate used in Competitor cannot be definitively evaluated without knowledge of the identity of the side chain alkyl group.

**Dialkyl polyethylene glycol:** The parent polymer polyethylene glycol (PEG) is a List 4 minimal risk "inert" and is considered to be non-toxic by EPA.[19] PEG has been patented for use bound to injectable proteins to increase their circulating time in the body.[20] The substitution of alkyl groups (identity unknown) for the hydroxyl groups in the parent polymer will probably alter the toxicity of the compound to some extent, but the precise effects are unknown.

## *5.4 Competitor Toxicity to Insects and Aquatic Organisms*

The acute toxicity of surfactants to insects and aquatic organisms is highly variable, depending on the chemical structure of the surfactant and the organism. In general, aquatic organisms are more susceptible to adverse effects from surfactants than terrestrial organisms because surfactants can adsorb to biological membranes (skin, gills) and disrupt biological functions.[21]

Some surfactants can be more toxic than the herbicides themselves. As an example, consider the toxicity of Roundup Original compared to that of Roundup Biactive[22] and glyphosate alone (Table D-10 in Appendix D). Roundup Original contains the well-studied surfactant polyoxyethylene amine, or POEA, and Roundup Biactive contains an unidentified surfactant that is not POEA. The $LC_{50}$ for frogs for Roundup Original was between 0.41-38 mg/L. In contrast, Roundup Biactive $LC_{50}$ values for frogs range from 43 mg/L to 492 mg/L. The frog $LC_{50}$ for glyphosate alone ranges from 39 mg/L to 400 mg/L.

Competitor has only slight acute toxicity to aquatic organisms, and it is one of the least-toxic surfactants used as an herbicide adjuvant (see Table 5-1 below). The chronic toxicity of the mixture remains unknown, although additional information is available on some of the components of the mixture, discussed below. There is no information on the aquatic toxicity of the mixture of this surfactant with Aquamaster, Garlon 4 Ultra, or Transline.

**Product mixture:** Competitor is slightly toxic to aquatic organisms. The fish $LC_{50}$ was 95 mg/L, and the $LC_{50}$ for aquatic invertebrates was 100 mg/L.[3] The fish and aquatic invertebrate NOEC was 50 mg/L.[23]

**Ethyl oleate:** No specific data on the aquatic toxicity of ethyl oleate was found. An EPA assessment indicates that its aquatic toxicity is anticipated to be low.[30]

**Sorbitan alkylpolyethyoxylate:** Because the specific alkyl group is not identified, it is not possible to search for toxicity information. For comparison, the aquatic toxicity of Polysorbate 80, the oleic acid sorbitan ester was found to be low, at greater than 100 mg/L.[24]

**Dialkyl polyoxyethylene glycol:** There is no information available on the toxicity of this specific PEG derivative to aquatic organisms.

Table 5-1 summarizes the aquatic toxicity of various surfactants used in herbicide applications.

## Table 5-1: Comparison of the Aquatic Toxicity of Various Surfactants

| Product | Ingredients | Surfactant Type | Taxa Group | $LC_{50}$ Range (mg/L) | NOEC Range (mg/L) | References |
|---|---|---|---|---|---|---|
| Competitor | Ethyl oleate, soribtan alkyl polyethoxylate ester, dialkyl polyoxyethylene glycol | Nonionic | Fish | 95 | 50 | 4, 23 |
| | | | Aquatic invertebrates | >100 | 50 | 4, 23 |
| Sylgard 309 | Heptamethyl trisiloxane, ethoxylated acetate, polyethylene glycol monallyl acetate, polyethylene glycol diacetate | Nonionic, silicone | Fish | NA | NA | |
| | | | Aquatic invertebrates | NA | NA | |
| Dye-Amic | Organosilicone, methylated vegetable oil | Silicone, oil-based | Fish | 23.2 | NA | 4 |
| | | | Aquatic invertebrates | 60 | NA | 4 |
| Kinetic | Organosilicone, polyoxypropylene-polyoxyethylene copolymer | Silicone | Fish | 13.9 | NA | 4 |
| | | | Aquatic invertebrates | 60.7 | NA | 4 |
| R-11 | 80% octylphenoxypolyethoxy-ethanol, 20% butanol and compounded silicone | Nonionic, silicone, OPE | Fish | 0.7–4.2 | 0.1-1.9 | 4, 25 |
| | | | Aquatic invertebrates | 0.42–19 | 8.4 | 4, 25 |
| X-77 | Alkylarylpoly (oxyethylene) glycols, free fatty acids, isopropyl alcohol | Nonionic, NPE/OPE | Fish | 4.2–4.3 | NA | 4 |
| | | | Aquatic invertebrates | 2 | | 4 |
| Liberate | Phosphatidylcholine (lecithin), methyl esters of fatty acids, alcohol ethoxylate | Nonionic, lecithin-based | Fish | 17.6 | 12.5 | 4 |
| | | | Aquatic invertebrates | 9.3 | 7.5 | 4 |
| LI-700 | Phosphatidycholine (lecithin), methylacetic acid, alkyl polyoxyethylene ether | Nonionic, lecithin-based | Fish | 17–700 | NA | 4 |
| | | | Aquatic invertebrates | 170 | NA | 4 |
| Mon 0818 | Polyoxyethyleneamine, 75% | Nonionic, amine | Fish | 1.4–4.9 | NA | 26 |
| | | | Amphibians | 1.1–2.7 | NA | 27, 28 |
| Cygnet Plus | 75% d-limonene and related isomers, 15% methylated vegetable oil, 10% alkyl hydroxypoly oxyethylene | Nonionic | Fish | 45 | 15–30 | 4 |
| | | | Aquatic invertebrates | 6.6 | 3 | 4 |
| Agridex | Proprietary, heavy range parrafin-based petroleum oil with polyol fatty acid esters and polyethoxylated derivatives | Nonionic, oil-based | Fish | 271–386 | NA | 4 |
| | | | Aquatic Invertebrates | >1,000 | NA | 4 |

$LC_{50}$ = lethal concentration for 50% of the test organisms. NOEC = No Observed Effect Concentration. NA = not available. OPE = octylphenol ethoxylate. NPE = nonylphenol ethoxylate.

## 5.5 Issues Related to Herbicide Use with Surfactants

The USFS has done a thorough review, updated in 2007, of issues related to the use of herbicides in combination with surfactants.[3] Here, we include the primary conclusions verbatim from that report and refer the reader to the report for additional details.

**Can surfactants cause pesticides to move more readily in the soil, or resolubilize, hence causing an increased risk of pesticide movement offsite into water? Can they cause effects to soil systems so that environmental decomposition of pesticides is affected?**

*Based on the following studies, it appears that the ability to increase the mobility of other materials throughout the soil profile is a function of the concentration of the surfactant in the soil solution. Surfactants have been used as tools for site amelioration of soil pollution, through their ability to solubilize hydrophobic compounds.*

*Surfactants applied to the soil, as part of a pesticide application, or in subsequent applications, would remain on the soil surface until decomposed unless driven down by water, thereby also diluting the surfactant in the soil/water system. Based on the studies that follow, for desorption to occur, concentrations of surfactants must be high, in the range of 1,000 ppm or more. This level is unlikely to be reached in normal applications.*

*It appears that biodegradation of pesticides can be affected by surfactants in the soil, however this too is concentration dependent similar to desorption effects. It appears that effects to pesticide biodegradation are through preferential degradation of the surfactant rather than through a toxic action on microorganisms.*

*Although the potential exists for surfactants to affect the environmental fate of herbicides in soil, any potential effects would be unlikely under normal conditions because of the relatively low concentration of surfactants in the soil/water matrix. Localized effects could be seen if a spill occurred on soil, so that concentrations of surfactant approached or exceeded about 1,000 ppm.*

**Do mixtures of herbicides and surfactants represent a greatly increased risk over the individual compounds alone (i.e., synergism)?**

*Surfactants, by their very nature, are intended to increase the effect of a pesticide by increasing the amount of pesticide that is in contact with the target (by reducing surface tension). This is not synergism, but more accurately is a reflection of increased dose of the herbicide active ingredient into the plant.*

*Although there is not much data in the technical literature, the references included in this paper indicate a lack of synergistic effects between surfactants and pesticides.*

**Do surfactants represent a unique risk to aquatic organisms?**

*There is little information in the scientific literature on effects of seed oils and silicone-based surfactants on aquatic organisms. There is more information on linear alcohol ethoxylates (LAE) and alkylphenol ethoxylates, such as nonylphenol ethoxylates (NPE) and octylphenol*

*ethoxylates (OPE) as these have more commercial uses in soaps and detergents, so environmental studies of water treatment plants have generated more data.*

*The interest in the NPE and OPE surfactants is largely driven by findings of estrogenic effects in fish and other aquatic organisms. From USDA 2003, based on various studies, it can be said that the threshold for estrogenic effects is generally above the threshold for other effects; hence protective levels of NPE exposure would encompass any concerns for estrogenic effects.*

*With linear alcohol ethoxylates, it appears that toxicity to aquatic organisms increases in relation to increased carbon chain length, but like the NPE-based surfactants, toxicity decreases with increasing ethoxylate length. It does appear that aquatic plants and most aquatic invertebrates are relatively insensitive to alcohol ethoxylates, although some specific invertebrate taxon may be identified as being more sensitive.*

*Effects on aquatic organisms are driven by the same dose-response principles as any other group of organisms (i.e., dosage thresholds can be determined for various effects). There are interspecies differences, as well as differences within species depending upon age, however the results of studies on the same surfactants are consistent with each other. It does appear that in general, the surfactants used in forestry can affect aquatic organisms at lower doses than for terrestrial organisms.*

**Do surfactants represent a unique risk to mammals?**

*There is little information in the scientific literature on effects of seed oils and silicone-based surfactants on mammals beyond some basic acute testing results as displayed in Table 1. There is more information on alkylphenol ethoxylates, such as nonylphenol ethoxylates (NPE). The interest in the alkylphenol ethoxylates surfactants is largely driven by findings of estrogenic effects. From USDA 2003, based on various studies, it can be said that the threshold for estrogenic effects is generally above the threshold for other effects; hence protective levels of NPE exposure would encompass any concerns for estrogenic effects.*

**Do surfactants affect the absorption rate of herbicides through the skin?**

*Various surfactants are used in products applied to the skin, including pharmaceuticals. There is little research on the non-ionic surfactants that are commonly used in pesticide applications. The exception is the alkylphenol ethoxylates, since this class of surfactants is also used in consumer products, such as hair dyes and cosmetics.*

*What research there is show that for a surfactant to increase the absorption of another compound, the surfactant must affect the upper layer of the skin. Without some physical effect to the skin, there will be no change in absorption as compared to the other compound alone.*

*The studies discussed below indicate that in general non-ionic surfactants have less of an effect on the skin, and hence absorption, then anionic or cationic surfactants. Compound specific studies indicate that the alkylphenol ethoxylates generally have little or no effect on absorption of other compounds. In several studies, the addition of a surfactant actually*

*decreased the absorption through the skin. It would appear that, given the data available here, there is little support for the contention that the addition of surfactants to herbicide mixtures would increase the absorption through the skin of these herbicides.*

## 5.6 Blazon Blue Dye Toxicity

There is even less information on the identity and toxicity of dyes than there is on surfactants. The USFS summarized the available literature in a 1997 document.[29] The blue dye, Blazon, is added to herbicide application mixtures to mark areas that have been treated. It is a water-soluble, nonionic polymeric colorant. As with most colorant products, the active ingredients are proprietary; the MSDS only indicates that it is non-hazardous and non-toxic. The report from the San Francisco Estuary Spartina Project Report found a single $LD_{50}$ for rats of >5,000 mg/kg for Blazon. Blazon is considered practically non-toxic by the oral route, is a mild skin irritant and not mutagenic. No other information is available.

The product information sheet reports that the product is non-staining to the skin or clothing. The colorant is typically added at a rate of 3 quarts per 100 gallons of solution, or 16 to 24 ounces per acre sprayed. The effects of Blazon Blue dye on nontarget terrestrial and aquatic species is unknown.

## 5.7 Environmental Fate and Transport

Several studies are available regarding the environmental fate of the components in the surfactant Competitor or the dye Blazon. For those ingredients with no data, generalizations can be made based on molecular structure and data on related compounds, but no detailed studies are available for most of the specific ingredients in these products. Without essential information such as half-life, water solubility, $K_{oc}$, $K_H$, and $K_{ow}$, it is difficult to predict the potential for long-term runoff, as well as potential dermal and inhalation exposures for workers, the general public and wildlife.

**Ethyl oleate:** Ethyl oleate has low water solubility (10 mg/L), moderate vapor pressure (0.01 mm Hg), and a high $K_{oc}$ of > 10,000 mL/g,[30] indicating a strong tendency to bind to the organic matter in soils. Ethyl oleate is degraded rapidly in the environment through microbial action.[31] The degradation product, oleic acid, has a half-life of less than one day, and a log $K_{ow}$ of approximately 3.0.[32]

**Sorbitan alkylpolyethoxylates:** Because the alkyl group that is part of this polymer is not identified, no environmental fate data specific to this compound could be found.

**Dialkyl Polyethylene glycol (PEG):** The hydroxylated form of PEG is soluble in water, and has been found to be relatively stable to degradation in soil.[33] A two-phase decomposition process occurs: A fast initial phase (up to 21 days), followed by a much slower phase (after 28 days). The measured half-life was found to be 1,127 days for free PEG and 735 days for PEG bound to organic matter. These data suggest that PEG is relatively persistent in the environment. The dialkyl derivatives are likely to have similar persistence, based on the unreactivity of the ether linkage.[34] Several studies show that >98% of PEG ingested by animals is excreted in the feces.[35]

# References for Chapter 5

[1] US EPA. 2008. *Inert ingredients permitted in pesticide products.* US Environmental Protection Agency. 2008. http://www.epa.gov/opprd001/inerts/.

[2] Loveland Products. 2008. *Compendium of Herbicide Adjuvants.* Loveland Products, Inc. http://www.herbicide-adjuvants.com/

[3] USFS. 2007. Bakke, D. *Analysis of issues Surrounding the Use of Spray Adjuvants with Herbicides.* Original 2002, revision 2007. US Forest Service. http://www.fs.fed.us/r6/invasiveplant-eis/Region-6-Inv-Plant-Toolbox/Surfactants/Surfactants-Bakke-update-2007.doc.

[4] Pless, Petra. 2005. *Use of imazapyr to control invasive cordgrass (Spartina spp.) in the San Francisco Estuary.* Leson & Associates. Berkeley, CA.

[5] USFS 2006. Appendix E: Human Health Risk Assessment from *Draft Environmental Impact Statement, Diamond Vegetation Management Project,* Mt. Hough Ranger District, Plumas National Forest, Plumas County, California. US Department of Agriculture Forest Service. July 2006. http://www.fs.fed.us/r5/plumas/projects_and_plans/diamond_veg_management_project/pdf/appendE.pdf.

[6] Wilbur-Ellis. Competitor label. http://ag.wilburellis.com/Products/Pages/CompetitorModifiedVegetableOil.aspx.

[7] Personal communication with Scott Johnson of Wilbur Ellis. August 22, 2008.

[8] DePergola G, Kjellstrom C, Holm C, *et al.* 2006. The metabolism of ethyl sters of fatty acids in adipose tissue of rats chronically exposed to ethanol. *Alcoholism Clin Exp Res* 15(2): 184–189.

[9] US FDA. 2008. Everything Added to Food in the United States (EAFUS): A Food Additive Database. US Food and Drug Administration. http://www.foodsafety.gov/~dms/eafus.html.

[10] Rohm & Haas. 2008. *Ion Exchange Resins Industrial Processes,* http://www.amberlyst.com/fatty_acids.htm.

[11] NTP. 2004. *Abstract for Teratology—Polyoxyethylene Sorbitan Monooleate: Developmental toxicology of polyoxyethylene sorbitan monooleate (CAS #9005-65-6) in Sprague-Dawley CD Rats.* NTP Study TER91009. US National Toxicology Program. http://ntp.niehs.nih.gov/?objectid=0730AFC6-AB6F-8A04-CFF2C1037A209CB8.

[12] Wong DC, Dorn PB, Chai EY.1997. Acute Toxicity and structure-reactivity relationships of nine alcohol ethoxylate surfactants to fathead minnow and *Daphnnia magna*. *Environmental Toxicology and Chemistry* 16(9): 1970–1976.

[13] Wikipedia. 2008. *Polysorbate.* http://en.wikipedia.org/wiki/Polysorbate.

[14] a) Fruijtier-Pölloth C. 2005. Safety assessment on polyethylene glycols (PEGs) and their derivatives as used in cosmetic products. *Toxicology* 214(1–2):1–38.

b) Lanigan RS, Yamarik TA. 2001. Final Report on the safety assessment of PEG-6, -8, and-20 sorbitan beeswax. *Int J Toxicol* 20(6):27–38.

[15] Wilbur-Ellis. Competitor MSDS. http://ag.wilburellis.com/Products/Pages/CompetitorModifiedVegetableOil.aspx.

[16] EWG. 2008. *Skin Deep Cosmetics Database.* Environmental Working Group. http://www.cosmeticsdatabase.com/.

[17] US EPA. 2005. *Inert Reassessment—Members of the Sorbitan Fatty Acid Esters and the Polysorbates*. US Environmental Protection Agency. May 20, 2005. http://www.epa.gov/opprd001/inerts/sorbitan5-20-05.pdf.

[18] US NTP. 1992. Developmental Toxicology of Polyoxyethylene Sorbitan Monooleate (CAS #9005-65-6) in Sprague-Dawley CD® Rats. NTP Study: TER91009. US National Toxicology Program. October 1992. http://ntp.niehs.nih.gov/?objectid=0730AFC6-AB6F-8A04-CFF2C1037A209CB8.

[19] US EPA. 2008. *Inert Ingredients Permitted in Pesticide Products.* US Environmental Protection Agency. http://www.epa.gov/opprd001/inerts/lists.html.

[20] European Patent EP1019446. Degradable Poly(ethylene glycol) Hydrogels with Controlled Half-life and Precursors Therefor. http://www.freepatentsonline.com/EP1019446.html.

[21] Rosen MJ, Fang L, Morrall SW *et al.* 2001. The relationship between the interfacial properties of surfactants and their toxicity to aquatic organisms. *Environ Sci Tech* 35(5): 954–959.

[22] Tsui MTK, Chu LM. 2004. Comparative Toxicity of Glyphosate-Based Herbicides: Aqueous and Sediment Porewater Exposures. Arch. Environ. Contam. Toxicol. 46, 316 –323. DOI: 10.1007/s00244-003-2307-3.

[23] Wilbur-Ellis. 2005. *Memo to Aquatic Herbicide Users and Wildlife and Fisheries Agencies, Re: Wilbur-Ellis Competitor® Aquatic Surfactant Acute Toxicity Data.* March 22, 2005.

[24] Carlsson C, Johansson A-K, Alvan G, *et al.* 2006. Are pharmaceuticals potent environmental pollutants? Part II: Environmental risk assessments of selected pharmaceutical excipients. *Sci Tot Environ* 364: 88–95.

[25] Siemering GS, Hayworth JD, Greenfield BK. 2008. Assessment of potential aquatic herbicide impacts to California aquatic ecosystems. *Arch Envi Contam Toxicol.* DOI 10.1007/s00244-008-9137-2.

[26] Wan, W.T., R.G. Watts, and D.J. Moul, 1989, Effects of Different Dilution Water Types on the Acute Toxicity to Juvenile Pacific Salmonids and Rainbow Trout of Glyphosate and Its Formulated Products, Bull.Environ.Contam.Toxicol. 43(3): 378-385.

[27] Howe, C et al. 2004. Toxicity of glyphosate-based pesticides to four North American frog species. *Env. Tox. and Chem.* 23(8): 1928-1938.

[28] Perkins, P, H Boermans, G Stephenson. 2000. Toxicity of glyphosate and triclopyr using the frog embryo teratogenesis assay-*Xenopus*. *Env. Tox. and Chem*. 19(4): 940-945.

[29] USFS. 1997. Use and Assessment of Marker Dyes Used with Herbicides. Written by Syracuse Environmental Research Associates, December 21, 1997. http://www.fs.fed.us/foresthealth/pesticide/pdfs/091602_markerdye**s**.pdf.

[30] US EPA. 1994. *Draft Cleaner Technologies Substitutes Assessment (CTSA): Screen Reclamation Chemicals, Chapter 2.* US Environmental Protection Agency, EPA 744R-94-005a, September 1994. http://www.epa.gov/dfe/pubs/screen/ctsa/ch02.html.

[31] ScienceLab.com. MSDS for Ethyl Oleate. http://www.sciencelab.com/xMSDS-Ethyl_Oleate-9927169.

[32] JT Baker. MSDS for Oleic Acid. http://www.jtbaker.com/msds/englishhtml/o3596.htm.

[33] Abdalla AL, Regitano JB, Tornisielo VL, *et al.* 2005. Biodegradation of polyethylene glycol (PEG) in three tropical soils using radio labeled PEG. *Animal Feed Sci Tech* 122 (1–2): 187–193.

[34] White GF, Russell NJ, Tidswell EC. 1996. Bacterial Scission of Ether Bonds. *Microbiol Rev* 60(1): 216–232.

[35] (a) Landau *et al.* 2002 as cited in Abdalla *et al.*, reference 34.

(b) Till and Downes. 1965 as cited in Abdalla *et al.*, reference 34.

(c) Clark *et al.* 1972 as cited in Abdalla *et al.*, reference 34.

(d) Ramanzin *et al.* 1990 as cited in Abdalla *et al.*, reference 34.

(e) Mambrini and Peyraud. 1991 as cited in Abdalla *et al.*, reference 34.

# Chapter 6—Recommendations

# 6 Table of Contents — Recommendations

**6.1 GENERAL RECOMMENDATIONS ..... 6-3**
**6.2 RECOMMENDATIONS FOR PROTECTION OF AQUATIC LIFE ..... 6-3**
6.2.1 SPILLS AND SPRAY DRIFT ..... 6-3
6.2.2 LONG-TERM RUNOFF ..... 6-3
**6.3 RECOMMENDATIONS FOR PROTECTION OF WORKERS ..... 6-4**
**6.4 RECOMMENDATIONS FOR PROTECTION OF THE GENERAL PUBLIC ..... 6-5**
**6.5 RECOMMENDATIONS FOR PROTECTION OF TERRESTRIAL WILDLIFE ..... 6-5**
**6.6 RECOMMENDATIONS FOR ONGOING MAINTENANCE ..... 6-5**

## 6.1 General Recommendations

The use of herbicides on Mount Sutro has the potential to have have unintended impacts on humans and terrestrial and aquatic wildlife. This risk assessment provides information on the types of impacts that can be anticipated for the selected herbicides under the proposed conditions of use, as well as a summary of the data gaps that make it difficult to have full knowledge of the potential impacts.

The following sections highlight specific recommendations for protection of workers, the general public, and terrestrial and aquatic wildlife if UCSF determines that herbicides will be used extensively on Mount Sutro.

## 6.2 Recommendations for Protection of Aquatic Life

### 6.2.1 Spills and Spray Drift

Avoidance of herbicide spills to water bodies is essential for protection of aquatic and terrestrial life. The probability of spills can be minimized through use of the following application guidelines:

1. Transport concentrated pesticide products in a spill-proof, sealed container above and beyond the product container. The volume of concentrated product being transported on the site at any given time should be limited to less than 20 gallons.
2. Spill cleanup materials will be available in all vehicles used for herbicide applications. Any vehicle transporting herbicide shall carry absorbent material on-board at all times in a quantity sufficient to contain a spill of the entire volume of herbicide being transported on the vehicle.
3. All mixing and loading should be done in a manner to contain any spills that might occur during transfers and should not be done near a water body.
4. In order to minimize site contamination and exposure from accidental spills, any spill of concentrated or dilute herbicide onto land should be treated immediately with materials that will absorb the spilled liquid, followed by removal of the contaminated earth and absorbent material into waste containers and proper disposal of all such material.
5. Triclopyr should not be applied within 50 feet of a stream. If the dry Woodland Creek streambed is to be treated, only Aquamaster should be used and applications should be conducted in early summer, providing the maximum time for herbicide degradation to occur before the rainy season.
6. Avoid spray drift to water bodies by not applying herbicides within 50 feet of a stream and by treating cut stumps with brush or wick application methods.

### 6.2.2 Long-term Runoff

Reduction in herbicide contamination from long-term runoff to Woodland Creek and puddles or pools on the Reserve can be minimized through use of the following application guidelines:

1. Avoid using glyphosate and triclopyr in areas with sandy/gravelly soils on steep slopes.
2. Limit applications to each site to once per year.
3. Limit the number of acres treated in each watershed in a given year.

4. Use the minimum herbicide application rate that can still accomplish the job, rather than the maximum application rate, particularly for cut-stump treatments. In practice, this would be a five percent solution of product, instead of a 50% solution.
5. To reduce off-target impacts, cut-stump applications should be conducted by painting or wicking application methods, not spray applications.
6. Do not apply triclopyr within 50 feet of a stream. If the dry Woodland Creek streambed is to be treated, only Aquamaster should be used and applications should be conducted in early summer, providing the maximum time for herbicide degradation to occur before the rainy season.
7. Conduct herbicide applications before heavy rains begin and soils become saturated, no earlier than June 1 and no later than December 1. Areas in closer proximity to private property should be treated early in the season to allow maximum time for degradation of herbicides before the rainy season begins.
8. In particularly sensitive areas, e.g. near Woodland Creek or the flatter areas where puddles may form that amphibians and aquatic invertebrates may use as breeding habitat, applications should be performed exclusively by staff holding a DPR Qualified Applicator Certificate with Forest and Right-of-Way specialty endorsements.
9. Depressions near heavily treated areas should be filled in to prevent formation of puddles that may be used as breeding habitat by amphibians and aquatic invertebrates.

## *6.3 Recommendations for Protection of Workers*

Worker exposures can be mitigated by adherence to the following measures. Spill prevention is the highest priority.

1. Applicators should wear gloves, protective footwear, goggles, and coveralls. An eyewash bottle and extra pairs of clean gloves, coveralls, soap, and water should be available in each vehicle for washing if workers are exposed.
2. If workers accidentally spill herbicide on themselves, they should wash the affected area as soon as possible.
3. Mixer-loaders should wear gloves, rubber boots, goggles, coveralls, and a protective apron.
4. All mixing and loading should be done in a manner to contain any spills that might occur during transfers and should not be done near a water body.
5. Spill cleanup materials should be available in all vehicles used for herbicide applications.
6. Within 30 feet (or within a feasible distance) of all roads and trails, areas to be treated should be mowed or pruned to less than knee height (approximately 2 feet) or lower prior to treatment to minimize worker general exposure from contacting treated vegetation and reducing the probability of spraying honeybees and small mammals. No foliar applications should be made to vegetation above 100 centimeters in height.
7. Applicators should spray in a downward direction to prevent spray drift from above.
8. To reduce worker general exposures, cut-stump applications should be conducted by painting or wicking application methods, not spray applications.
9. Two layers of gloves should be used by workers applying triclopyr-based herbicides (Garlon 4 Ultra).
10. Backpack applicators that incorporate some form of physical separation between the backpack sprayer and the applicator should be used by workers applying triclopyr-based

herbicides (Garlon 4 Ultra) to prevent spills onto the applicator from a leaking backpack sprayer.

## 6.4 Recommendations for Protection of the General Public

General public exposures can be mitigated by adherence to the following measures. Notification and trimming of vegetation prior to treatment to reduce the probability of dermal contact are the highest priorities.

1. All trailheads and other access points leading to the treatment area should be posted prior to treatment in order to minimize the probability of the general public contacting treated vegetation.
2. Blazon blue dye shall be used with all treatments to clearly delineate the treated areas and signs should explain that contact with cut stumps and vegetation with dye visible should be avoided.
3. Treated areas should be posted for two weeks after the application.
4. Avoid applications on weekends to minimize exposures to the general public.
5. No applications should be conducted on weekends to reduce the probability of exposures to the general public from application activities.
6. No applications should be conducted when wind speeds exceed five miles per hour or in locations where prevailing winds might carry spray drift onto private property.
7. Within 30 feet (or within a feasible distance) of all roads and trails, areas to be treated should be mowed or pruned to less than knee height (approximately 2 feet) or lower prior to treatment to minimize the probability of the general public contacting treated vegetation. No foliar applications should be made to vegetation above 100 centimeters in height to reduce the probability of drift onto people.

## 6.5 Recommendations for Protection of Terrestrial Wildlife

Terrestrial wildlife exposures can be mitigated by adherence to the following measures. Spill prevention and cleanup is the highest priority.

1. Avoid spills and spray drift to water bodies (see Section 6.2.2 above).
2. Within 30 feet (or within a feasible distance) of all roads and trails, areas to be treated should be mowed or pruned to less than knee height (approximately 2 feet) or lower prior to treatment to minimize the probability of spraying honeybees and small mammals.
3. To reduce off-target impacts to small mammals, insects and their prey, cut-stump applications should be conducted by painting or wicking application methods, not spray applications.

## 6.6 Recommendations for Ongoing Maintenance

It is important to recognize the uncertainties and limitations of the hazard assessment process through which the RfDs are set, particularly for herbicides or adjuvants with minimal data. Because of these uncertainties, UCSF's incorporation of limitations on herbicide use over time will help to reduce impacts. Triclopyr use should be limited to spot treatments only, and the less toxic Aquamaster should be used whenever possible, especially in areas closest to Woodland Creek and Watershed 4 that has potential to generate runoff that may be intercepted by private property. The five-year plan developed by UCSF limits the maximum amount of herbicide that

can be used over time, which will ensure that any herbicide use after completion of the initial two years of treatment will be on a steadily decreasing trajectory until only maintenance applications are being conducted, up to a maximum of one pound per acre per year.

# APPENDIX H

HYDROLOGY CALCULATIONS

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

**Summary of SCS Runoff, Peak Discharge and Synthetic Hydrograph Results**

| Watershed | Area (mi.2) | Pre-Project Qp (cfs) | Post-Project Qp (cfs) | Pre-Project Runoff Volume ($ft.^3$) | Post-Project Runoff Volume ($ft.^3$) |
|---|---|---|---|---|---|
| 1 | 0.02088 | 3.338 | 2.792 | 62806 | 56307 |
| 2 | 0.00074 | 0.115 | 0.095 | 2101 | 1869 |
| 3 | 0.02220 | 2.939 | 2.379 | 62651 | 55381 |
| 4 | 0.00389 | 0.586 | 0.480 | 11018 | 9797 |
| 5 | 0.00040 | 0.065 | 0.054 | 1134 | 1009 |
| 6 | 0.00302 | 0.462 | 0.379 | 8547 | 7601 |
| 7 | 0.00303 | 0.418 | 0.341 | 8520 | 7578 |
| 8 | 0.00234 | 0.324 | 0.265 | 6593 | 5864 |
| 9 | 0.01386 | 1.723 | 1.405 | 38814 | 34498 |
| 10 | 0.00754 | 1.030 | 0.841 | 21231 | 18866 |
| 11 | 0.01006 | 1.410 | 1.152 | 28353 | 25198 |
| 12 | 0.00468 | 0.675 | 0.552 | 13207 | 11739 |
| 13 | 0.00541 | 0.797 | 0.653 | 15291 | 13593 |

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 1** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.021 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.015 | 72.7 |
| Brush | Good | D | 73 | 0.004 | 19.9 |
| Paved Road w/Open Ditches | | D | 93 | 0.002 | 7.5 |

Area Weighted CN = 77.4

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 300 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.40 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 24.0 min.

Shallow Concentrated Flow

| Segment ID | BC |
|---|---|
| Surface Description | Unpaved |
| Flow Length, L (ft) | 25.3 |
| Watercourse Slope, s (ft/ft) | 0.62 |

| | |
|---|---|
| Average Velocity, V (ft/s) | 12.7 |
| Travel Time, T = L / 60V (min) | 0.03 |

*For Unpaved, V = 16.1345 $(s)^{0.5}$

Travel Time, $T_{BC}$ = 0.03 min.

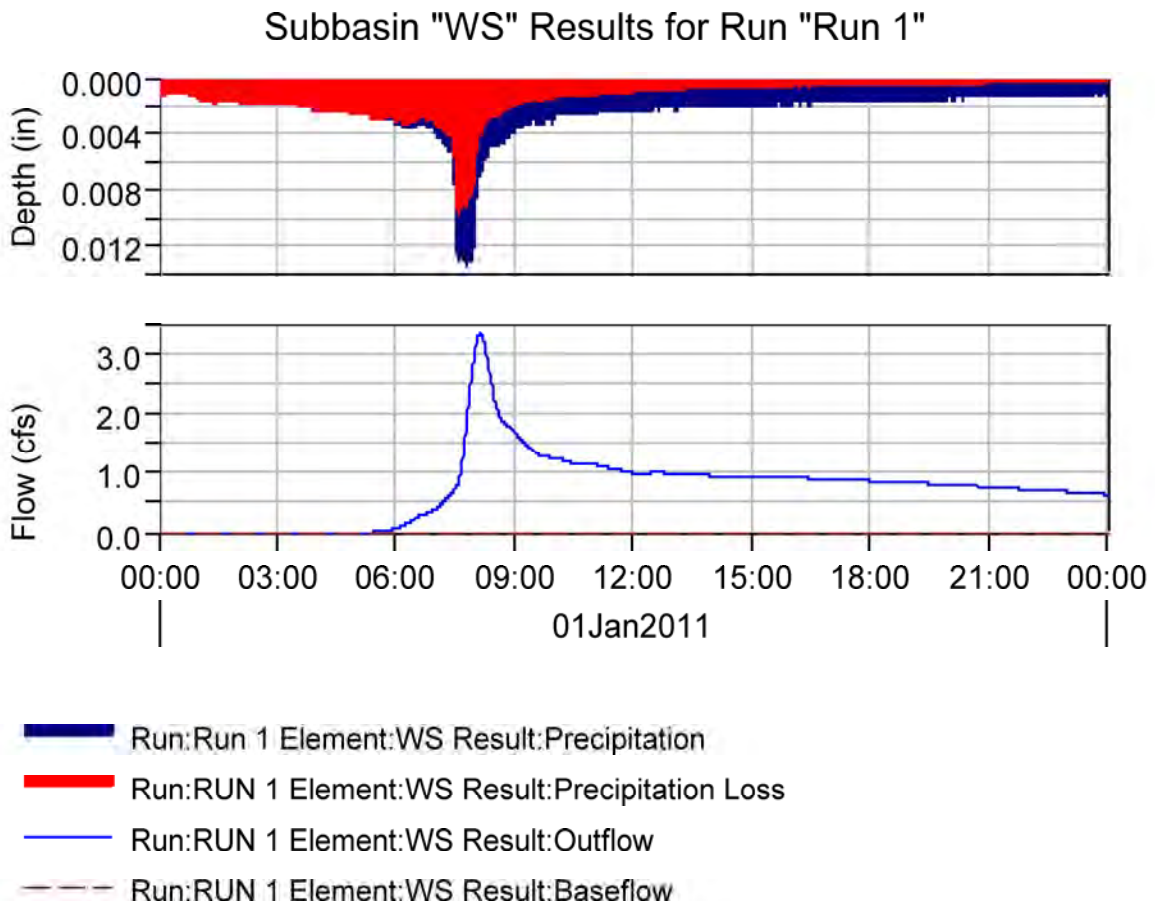
$Tc = T_{AB} + T_{BC}$ = 24.08 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6$ = 14.45 min.

Determination of Time Interval, dt

dt = (0.133 * Tc) / 2 = 1.60 min.


Subbasin "WS" Results for Run "Run 1"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
3.0
2.0
1.0
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 1 Element:WS Result:Precipitation
Run:RUN 1 Element:WS Result:Precipitation Loss
Run:RUN 1 Element:WS Result:Outflow
Run:RUN 1 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 1** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.021 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.004 | 18.2 |
| Brush | Good | D | 73 | 0.016 | 74.3 |
| Paved Road w/Open Ditches | | D | 93 | 0.002 | 7.5 |

Area Weighted CN = 75.2

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 300 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.40 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 24.0 min.

Shallow Concentrated Flow

| Segment ID | BC |
|---|---|
| Surface Description | Unpaved |
| Flow Length, L (ft) | 25.3 |
| Watercourse Slope, s (ft/ft) | 0.62 |

| | |
|---|---|
| Average Velocity, V (ft/s) | 12.7 |
| Travel Time, T = L / 60V (min) | 0.03 |

*For Unpaved, V = 16.1345 $(s)^{0.5}$

Travel Time, $T_{BC}$ = 0.03 min.

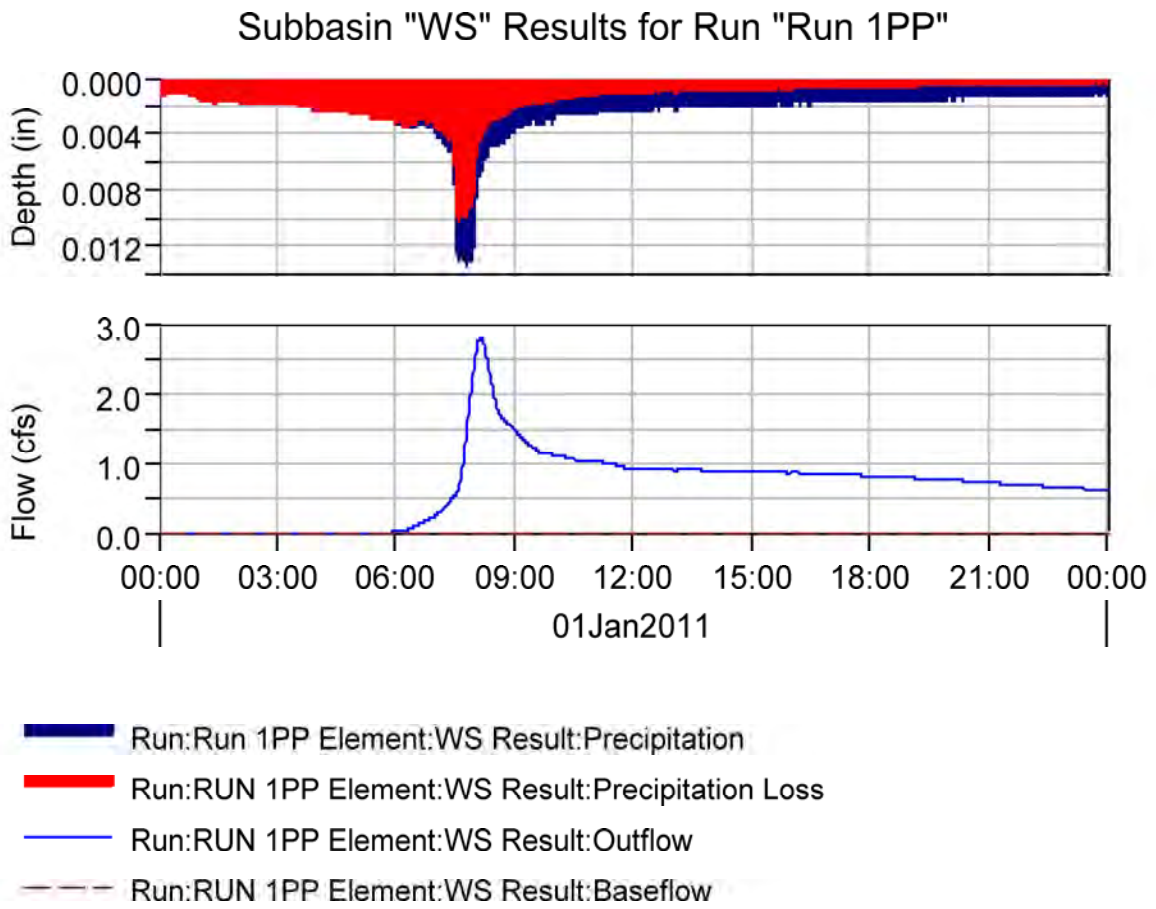
$Tc = T_{AB} + T_{BC}$ = 24.08 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6$ = 14.45 min.

Determination of Time Interval, dt

dt = (0.133 * Tc) / 2 = 1.60 min.


Subbasin "WS" Results for Run "Run 1PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
3.0
2.0
1.0
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 1PP Element:WS Result:Precipitation
Run:RUN 1PP Element:WS Result:Precipitation Loss
Run:RUN 1PP Element:WS Result:Outflow
Run:RUN 1PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 2** **Pre-Project Conditions**

Watershed Characteristics

Area, A = 0.00074 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00058 | 79 |
| Brush | Good | D | 73 | 0.00016 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 128.1 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.21 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 15.79 min.

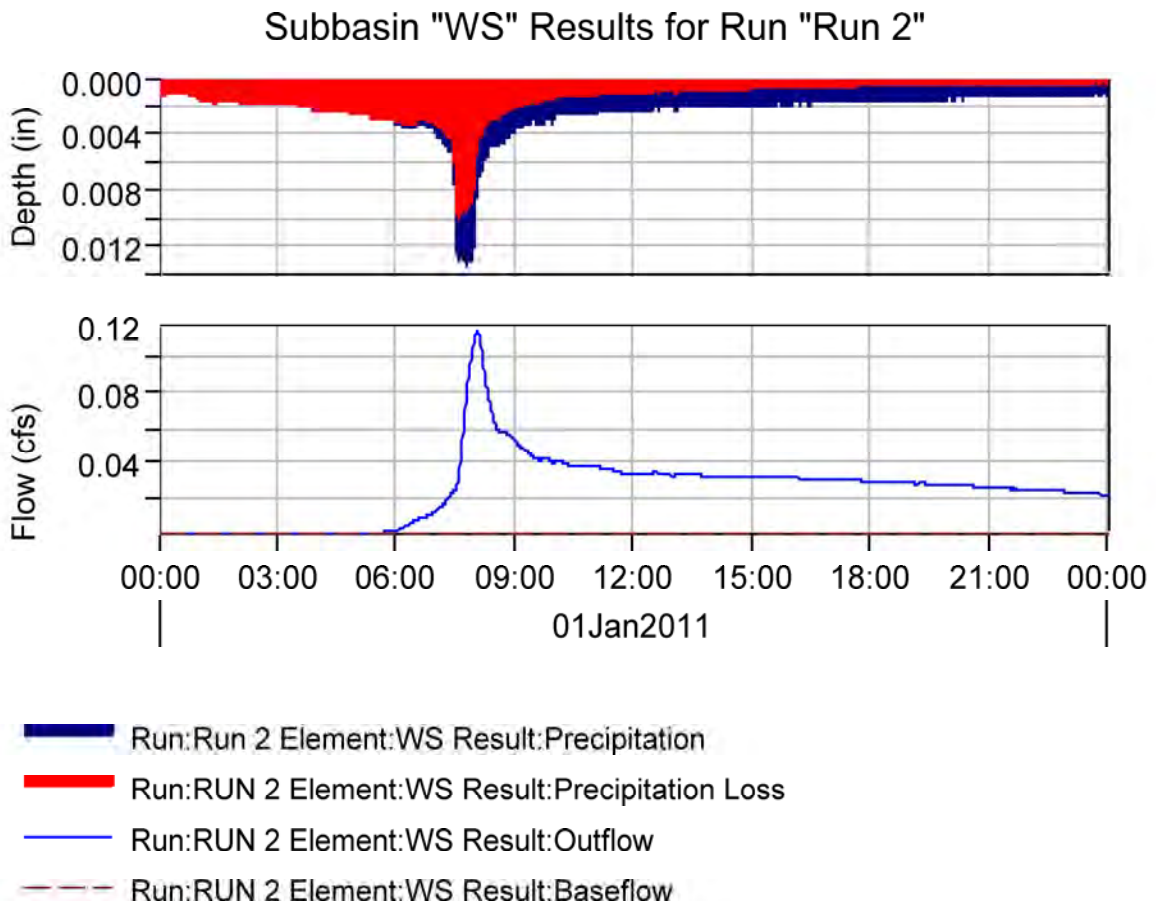
$Tc = T_{AB} =$ 15.79 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6 =$ 9.47 min.

Determination of Time Interval, dt

$dt = (0.133 * Tc) / 2 =$ 1.05 min.


Subbasin "WS" Results for Run "Run 2"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.12
0.08
0.04
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 2 Element:WS Result:Precipitation
Run:RUN 2 Element:WS Result:Precipitation Loss
Run:RUN 2 Element:WS Result:Outflow
Run:RUN 2 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 2** **Post-Project Conditions**

Watershed Characteristics

Area, A = 0.00074 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00015 | 20 |
| Brush | Good | D | 73 | 0.00060 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 128.1 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.21 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 15.79 min.

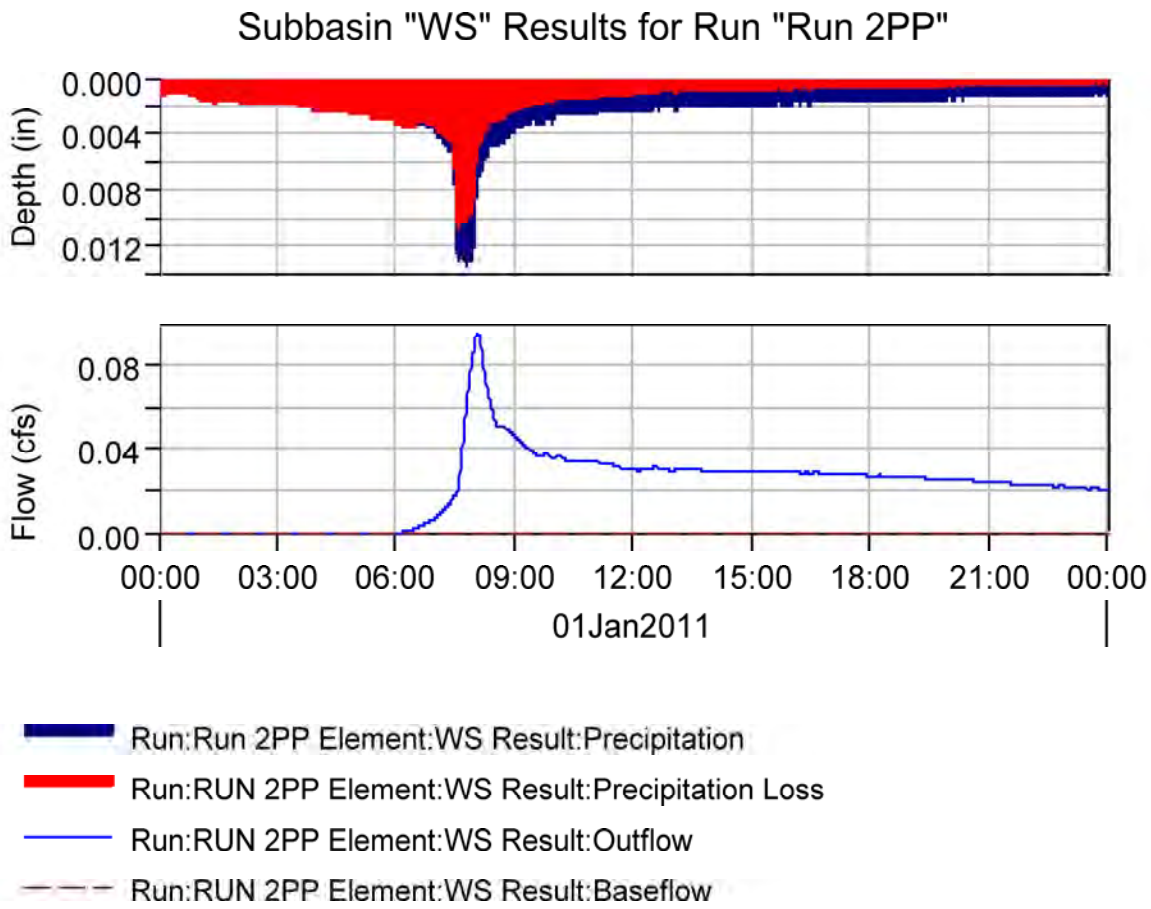
$Tc = T_{AB} =$ 15.79 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6 =$ 9.47 min.

Determination of Time Interval, dt

$dt = (0.133 * Tc) / 2 =$ 1.05 min.


Subbasin "WS" Results for Run "Run 2PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.08
0.04
0.00
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 2PP Element:WS Result:Precipitation
Run:RUN 2PP Element:WS Result:Precipitation Loss
Run:RUN 2PP Element:WS Result:Outflow
Run:RUN 2PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 3** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.02220 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.01733 | 78 |
| Brush | Good | D | 73 | 0.00474 | 21 |
| Paved Road w/Open Ditches | | D | 93 | 0.00013 | 1 |

Area Weighted CN = 76.2

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 300 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.16 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 34.31 min.

Shallow Concentrated Flow

| Segment ID | BC | CD | EF |
|---|---|---|---|
| Surface Description | Unpaved | Paved | Unpaved |
| Flow Length, L (ft) | 527.7 | 97.2 | 273.3 |
| Watercourse Slope, s (ft/ft) | 0.30 | 0.08 | 0.31 |
| Average Velocity, V (ft/s) | 8.8 | 5.6 | 9.0 |
| Travel Time, T = L / 60V (min) | 1.00 | 0.29 | 0.50 |

*For Unpaved, V = 16.1345 $(s)^{0.5}$

*For Paved, V = 20.3282 $(s)^{0.5}$

Travel Time, $T_{BD} = T_{BC} + T_{EF}$ = 1.79 min.

Channel Flow

| Segment ID | DE |
|---|---|
| Cross Sectional Area, A ($ft^2$) | 3.14 |
| Wetted Perimeter, P (ft) | 6.28 |
| Hydraulic Radius, R (ft) | 0.50 |
| Channel Slope, s (ft/ft) | 0.407 |
| Manning's *n* | 0.024 |
| Flow Length, L (ft) | 74.6 |
| $V = (1.486)(R^{2/3})(S^{1/2})/ n$ | 24.9 |

Travel Time, $T_{DE} = L / 60V$ = 0.05 min.

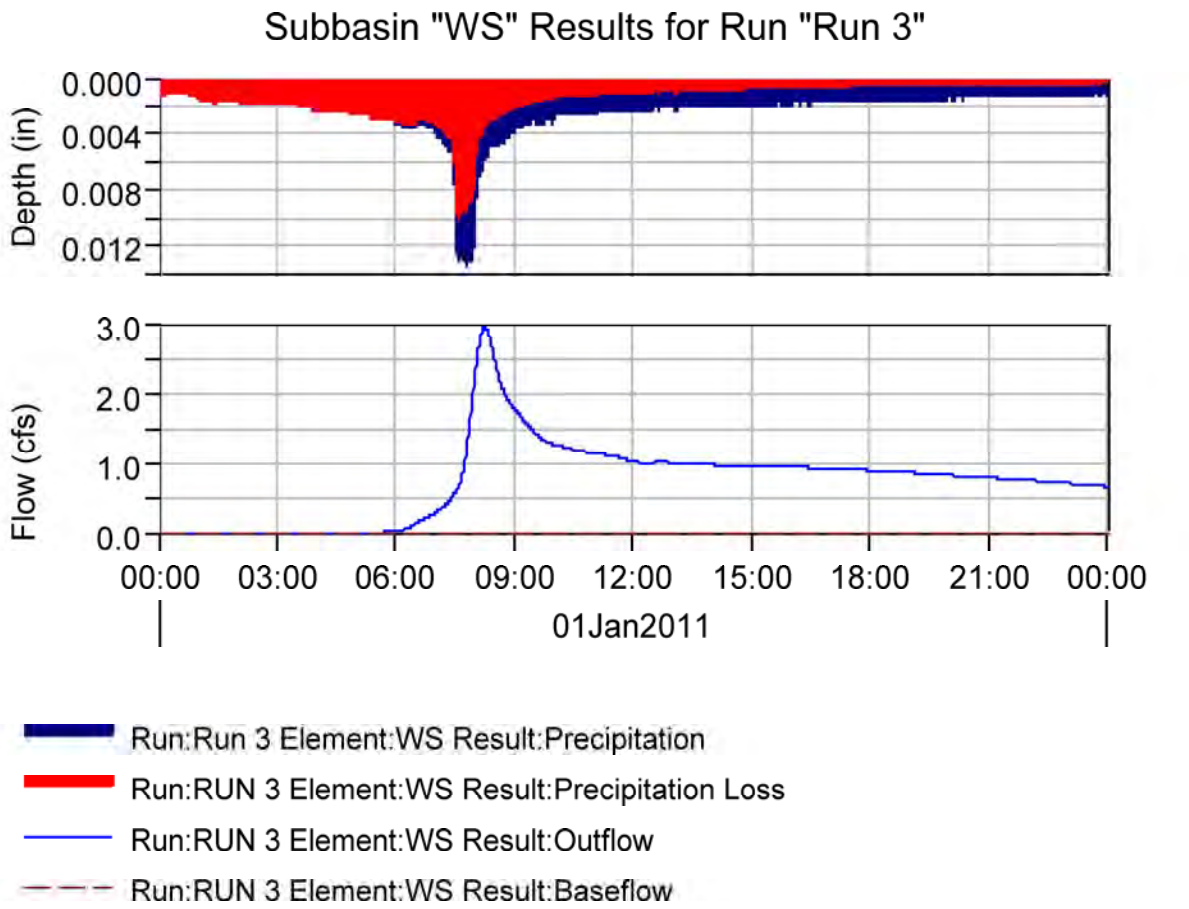
$Tc = T_{AB} + T_{BC} + T_{CD} + T_{DE} + T_{EF}$ = 34.36 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6$ = 20.61 min.

Determination of Time Interval, dt

$dt = (0.133 * Tc) / 2$ = 2.28 min.


Subbasin "WS" Results for Run "Run 3"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
3.0
2.0
1.0
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 3 Element:WS Result:Precipitation
Run:RUN 3 Element:WS Result:Precipitation Loss
Run:RUN 3 Element:WS Result:Outflow
Run:RUN 3 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 3** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.02220 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00394 | 18 |
| Brush | Good | D | 73 | 0.01813 | 82 |
| Paved Road w/Open Ditches | | D | 93 | 0.00013 | 1 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 300 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.16 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 34.31 min.

Shallow Concentrated Flow

| Segment ID | BC | CD | EF |
|---|---|---|---|
| Surface Description | Unpaved | Paved | Unpaved |
| Flow Length, L (ft) | 527.7 | 97.2 | 273.3 |
| Watercourse Slope, s (ft/ft) | 0.30 | 0.08 | 0.31 |
| Average Velocity, V (ft/s) | 8.8 | 5.6 | 9.0 |
| Travel Time, T = L / 60V (min) | 1.00 | 0.29 | 0.50 |

*For Unpaved, V = 16.1345 $(s)^{0.5}$

*For Paved, V = 20.3282 $(s)^{0.5}$

Travel Time, $T_{BD} = T_{BC} + T_{EF}$ = 1.79 min.

Channel Flow

| Segment ID | DE |
|---|---|
| Cross Sectional Area, A ($ft^2$) | 3.14 |
| Wetted Perimeter, P (ft) | 6.28 |
| Hydraulic Radius, R (ft) | 0.50 |
| Channel Slope, s (ft/ft) | 0.407 |
| Manning's *n* | 0.024 |
| Flow Length, L (ft) | 74.6 |
| $V = (1.486)(R^{2/3})(S^{1/2})/ n$ | 24.9 |

Travel Time, $T_{DE} = L / 60V$ = 0.05 min.

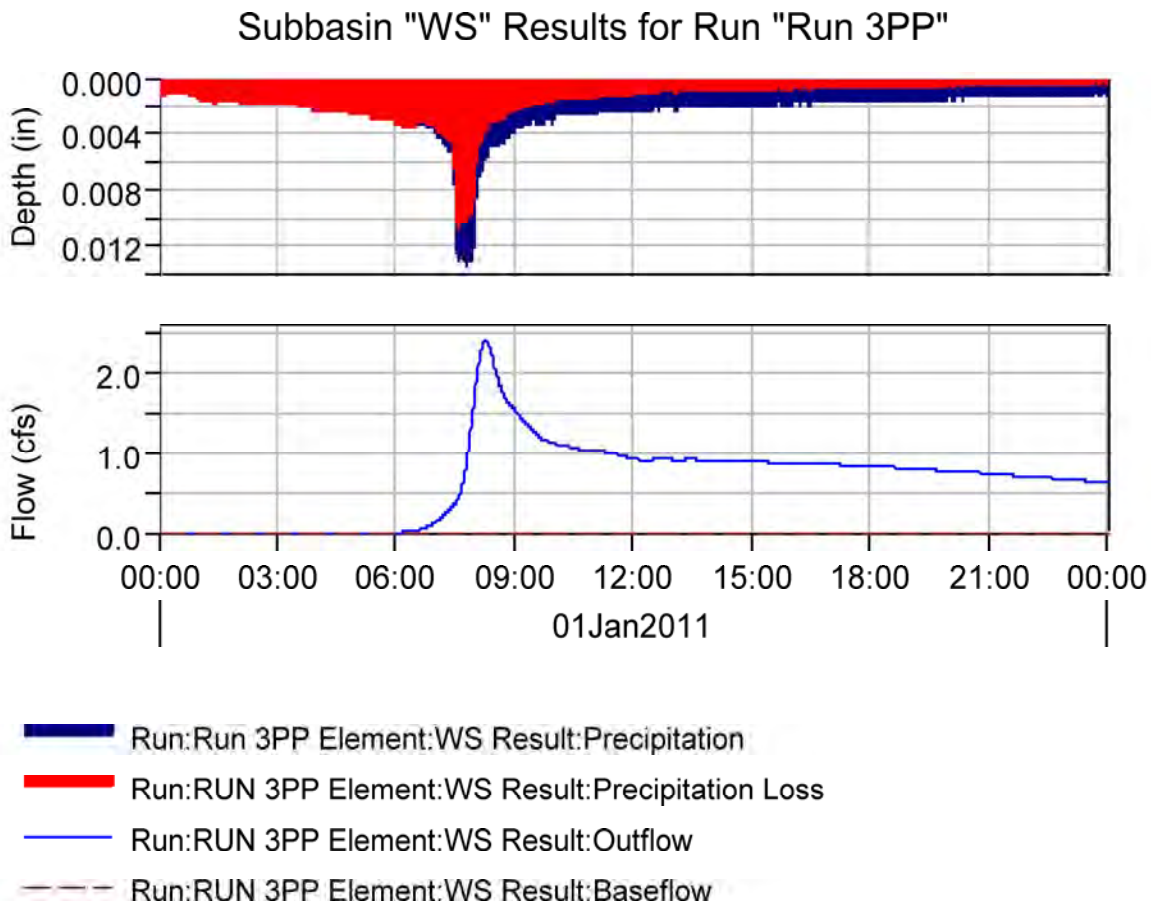
$Tc = T_{AB} + T_{BC} + T_{CD} + T_{DE} + T_{EF}$ = 34.36 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6$ = 20.61 min.

Determination of Time Interval, dt

$dt = (0.133 * Tc) / 2$ = 2.28 min.


Subbasin "WS" Results for Run "Run 3PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
2.0
1.0
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 3PP Element:WS Result:Precipitation
Run:RUN 3PP Element:WS Result:Precipitation Loss
Run:RUN 3PP Element:WS Result:Outflow
Run:RUN 3PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 4** **Pre-Project Conditions**

Watershed Characteristics

Area, A = 0.0039 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.0031 | 79 |
| Brush | Good | D | 73 | 0.0008 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 254.0 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.48 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 19.57 min.

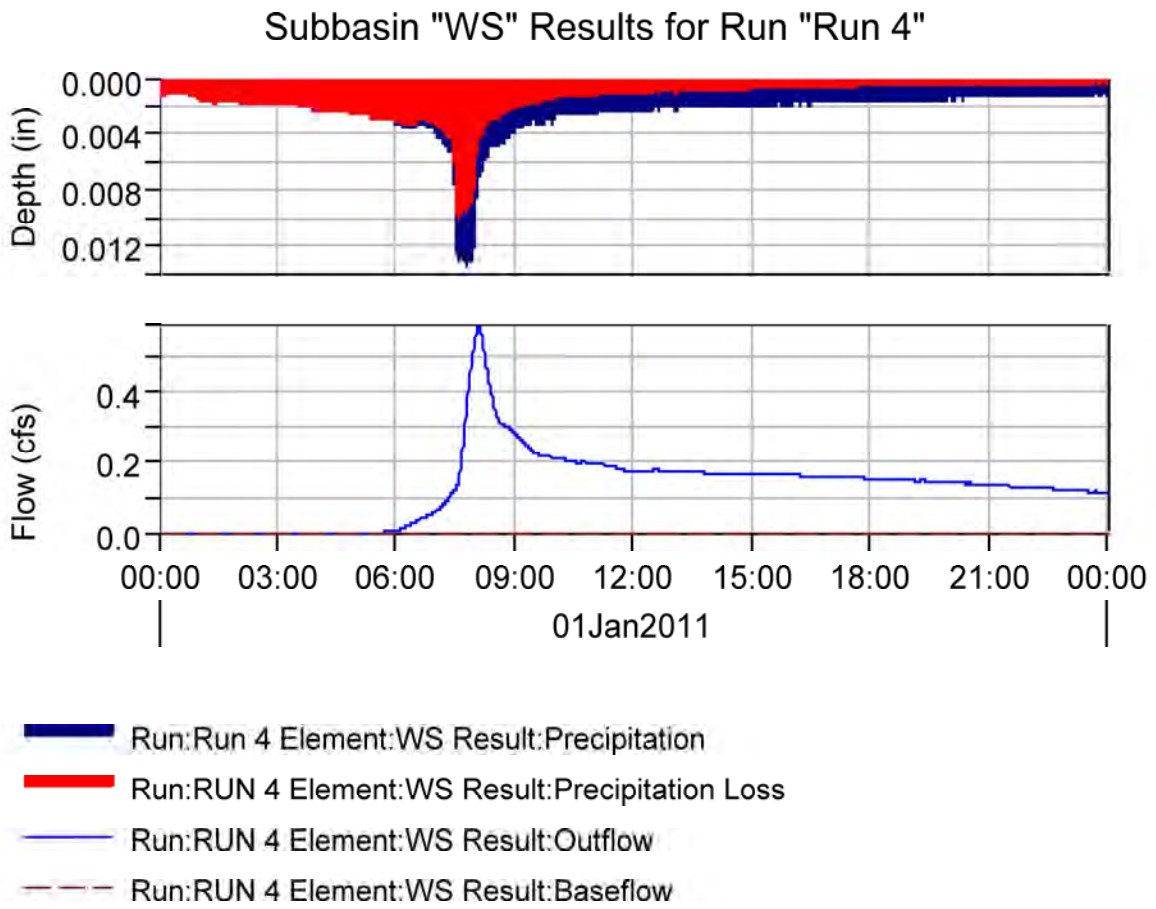
Tc = $T_{AB}$ = 19.57 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag}$ = Tc * 0.6 = 11.74 min.

Determination of Time Interval, dt

dt = (0.133 * Tc) / 2 = 1.30 min.


Subbasin "WS" Results for Run "Run 4"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.4
0.2
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 4 Element:WS Result:Precipitation
Run:RUN 4 Element:WS Result:Precipitation Loss
Run:RUN 4 Element:WS Result:Outflow
Run:RUN 4 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 4** **Post-Project Conditions**

Watershed Characteristics

Area, A = 0.0039 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.0008 | 20 |
| Brush | Good | D | 73 | 0.0031 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 254.0 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.48 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 19.57 min.

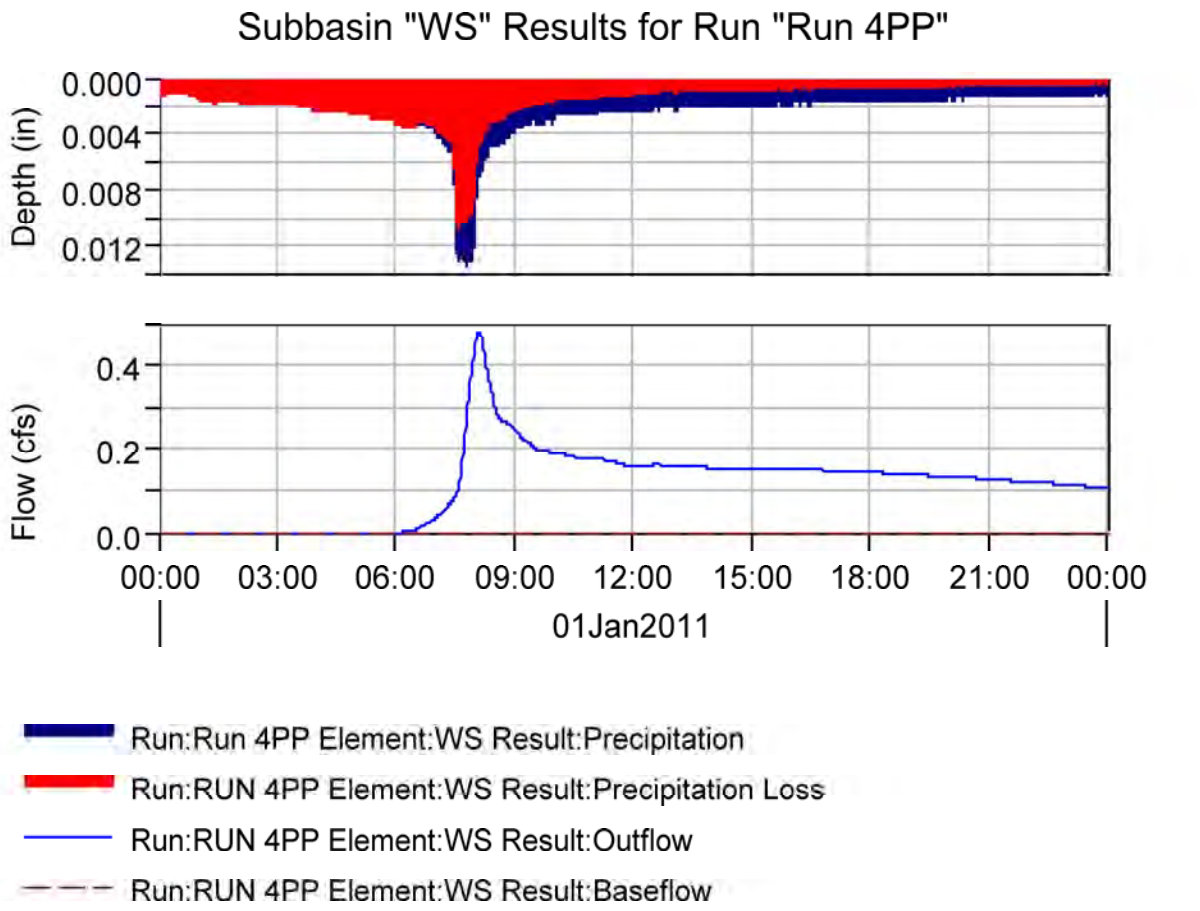
Tc = $T_{AB}$ = 19.57 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag}$ = Tc * 0.6 = 11.74 min.

Determination of Time Interval, dt

dt = (0.133 * Tc) / 2 = 1.30 min.


Subbasin "WS" Results for Run "Run 4PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.4
0.2
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 4PP Element:WS Result:Precipitation
Run:RUN 4PP Element:WS Result:Precipitation Loss
Run:RUN 4PP Element:WS Result:Outflow
Run:RUN 4PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 5** **Pre-Project Conditions**

Watershed Characteristics

Area, A = 0.0004 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00031 | 79 |
| Brush | Good | D | 73 | 0.00009 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 90.5 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.38 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 9.44 min.

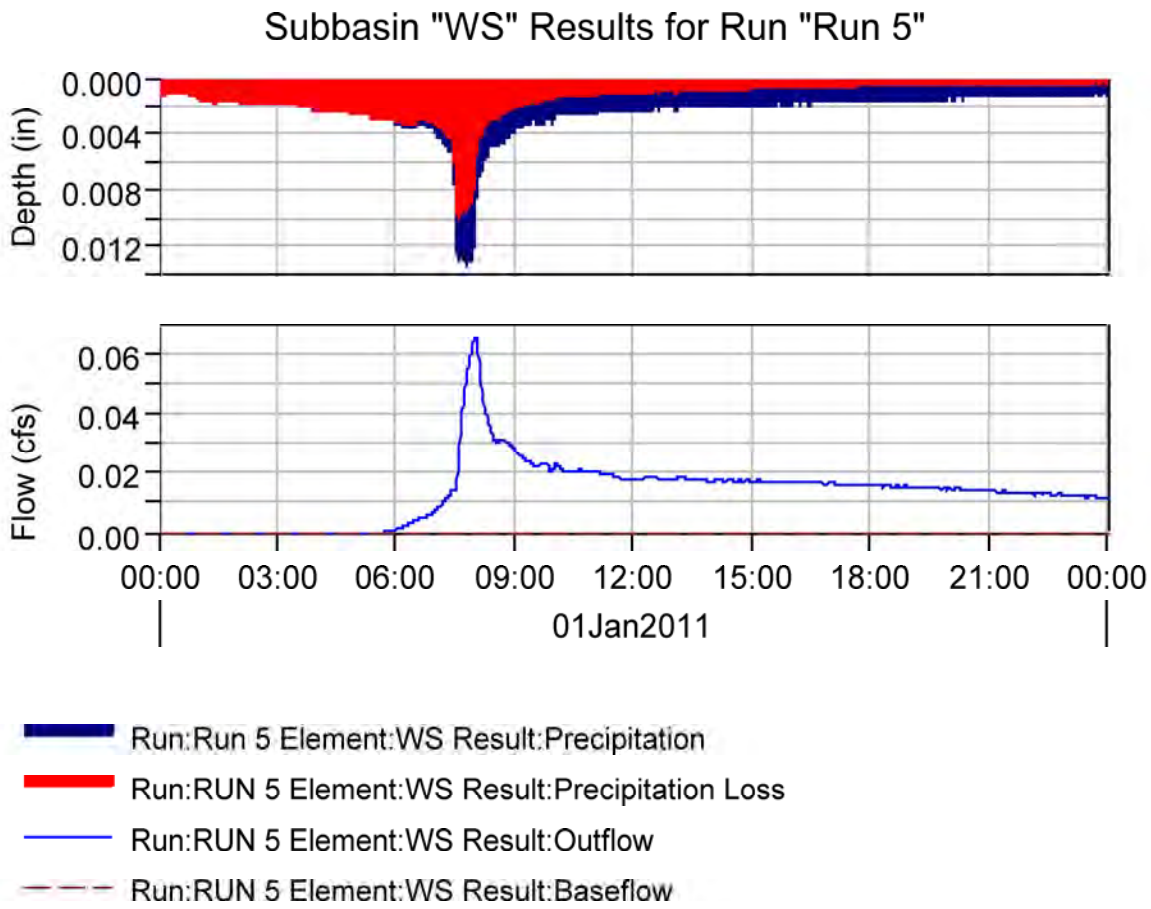
Tc = $T_{AB}$ = 9.44 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag}$ = Tc * 0.6 = 5.67 min.

Determination of Time Interval, dt

dt = (0.133 * Tc) / 2 = 0.63 min.


Subbasin "WS" Results for Run "Run 5"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.06
0.04
0.02
0.00
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 5 Element:WS Result:Precipitation
Run:RUN 5 Element:WS Result:Precipitation Loss
Run:RUN 5 Element:WS Result:Outflow
Run:RUN 5 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 5** **Post-Project Conditions**

Watershed Characteristics

Area, A = 0.0004 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00008 | 20 |
| Brush | Good | D | 73 | 0.00032 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 90.5 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.38 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 9.44 min.

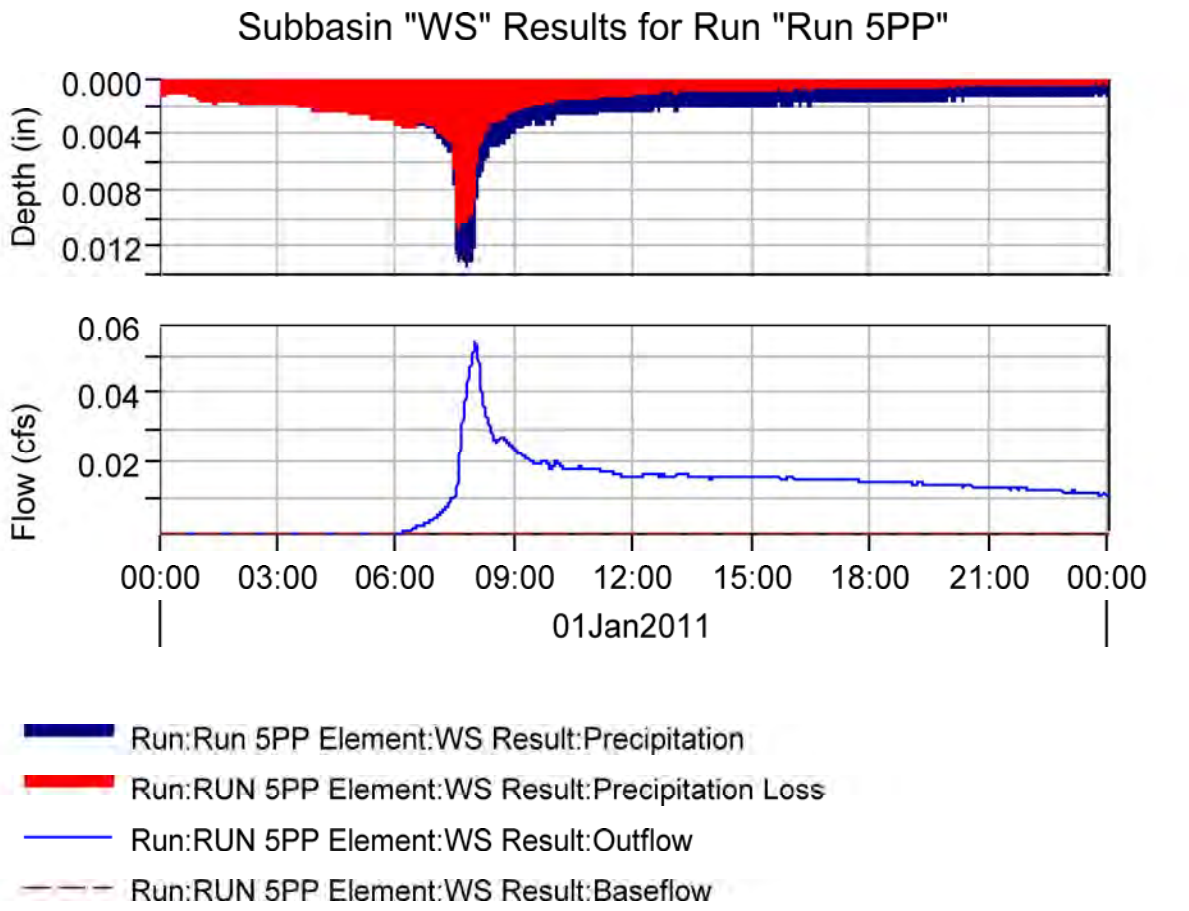
$Tc = T_{AB} =$ 9.44 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6 =$ 5.67 min.

Determination of Time Interval, dt

$dt = (0.133 * Tc) / 2 =$ 0.63 min.


Subbasin "WS" Results for Run "Run 5PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.06
0.04
0.02
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 5PP Element:WS Result:Precipitation
Run:RUN 5PP Element:WS Result:Precipitation Loss
Run:RUN 5PP Element:WS Result:Outflow
Run:RUN 5PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 6** **Pre-Project Conditions**

Watershed Characteristics

Area, A = 0.003 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.0024 | 79 |
| Brush | Good | D | 73 | 0.0006 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 152.9 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.22 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 17.71 min.

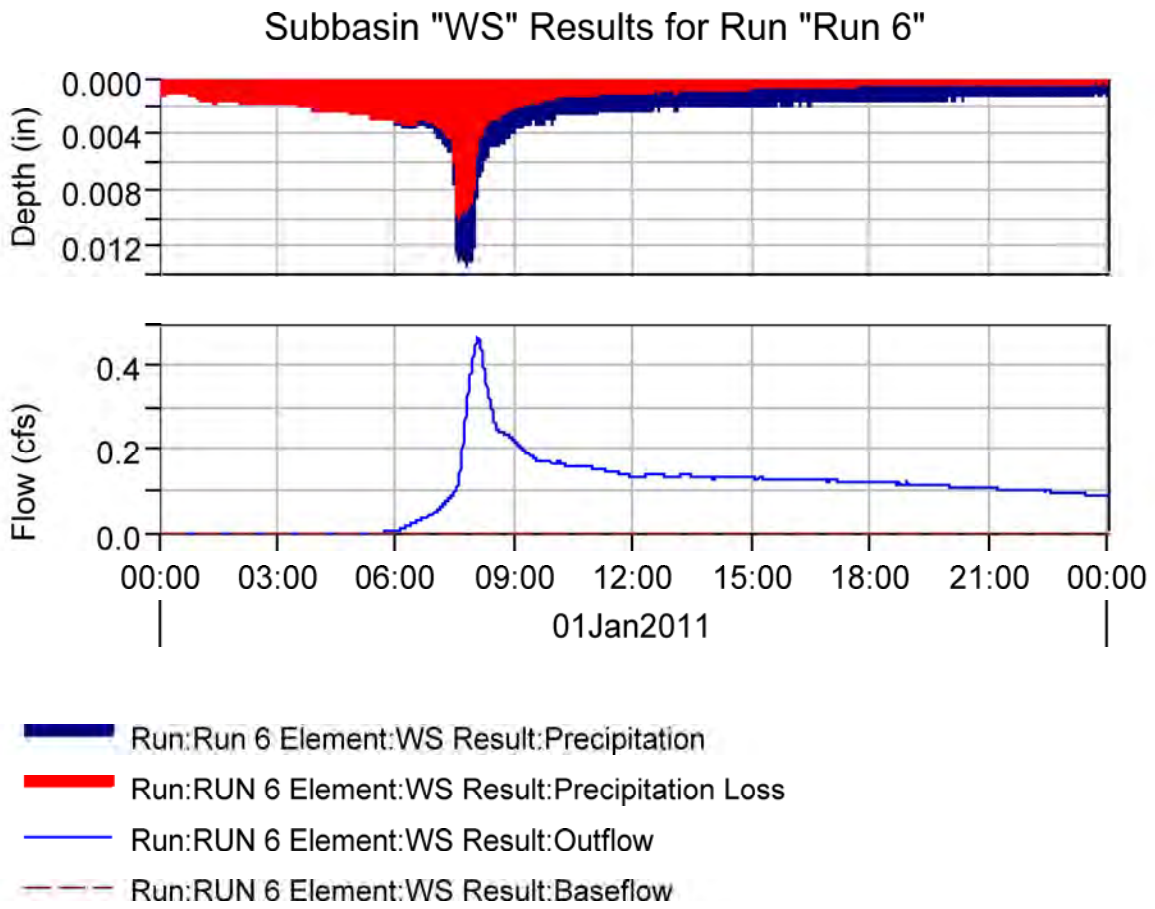
Tc = $T_{AB}$ = 17.71 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag}$ = Tc * 0.6 = 10.63 min.

Determination of Time Interval, dt

dt = (0.133 * Tc) / 2 = 1.18 min.


Subbasin "WS" Results for Run "Run 6"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.4
0.2
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 6 Element:WS Result:Precipitation
Run:RUN 6 Element:WS Result:Precipitation Loss
Run:RUN 6 Element:WS Result:Outflow
Run:RUN 6 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 6** **Post-Project Conditions**

Watershed Characteristics

Area, A = 0.003 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.0006 | 20 |
| Brush | Good | D | 73 | 0.0024 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 152.9 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.22 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 17.71 min.

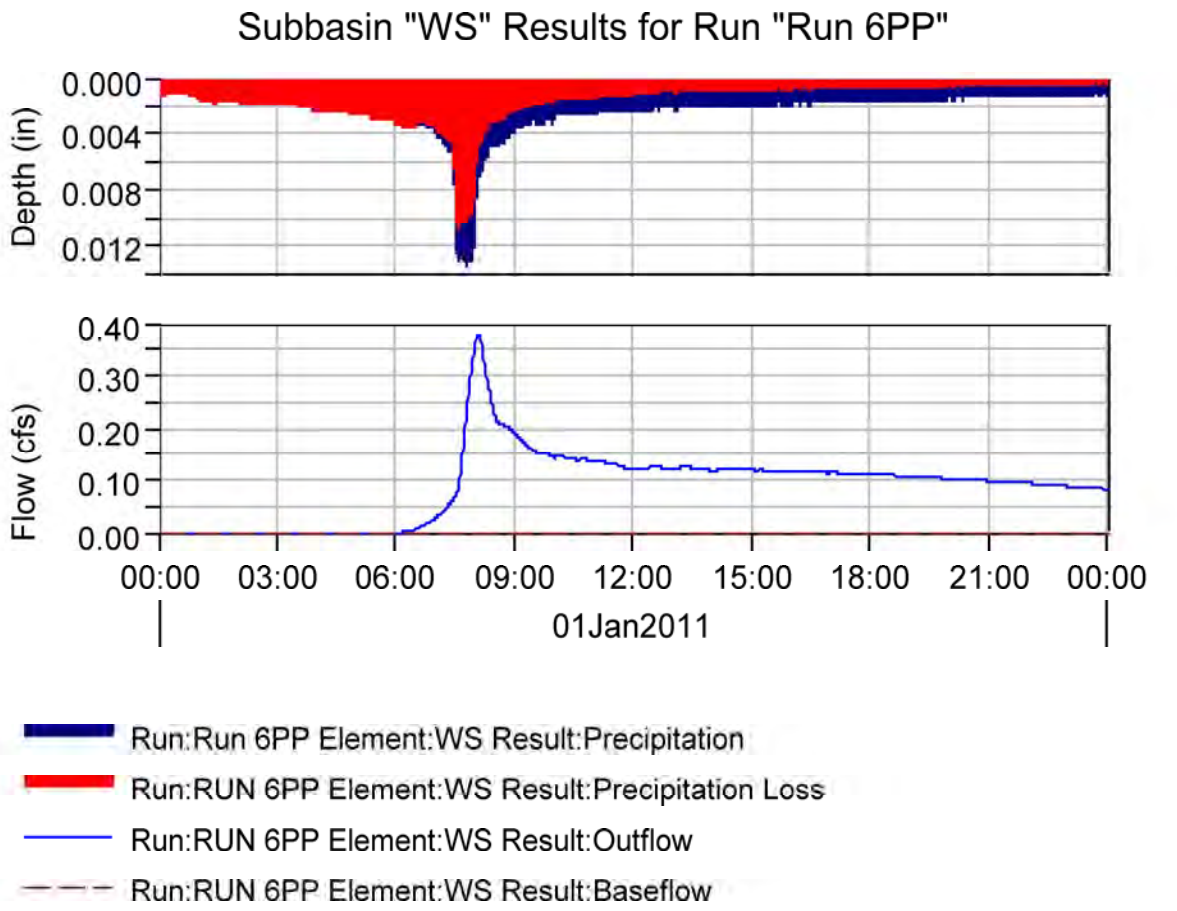
$Tc = T_{AB} =$ 17.71 min.

Determination of Lag Time, $T_{lag}$

$T_{Lag} = Tc * 0.6 =$ 10.63 min.

Determination of Time Interval, dt

$dt = (0.133 * Tc) / 2 =$ 1.18 min.


Subbasin "WS" Results for Run "Run 6PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.40
0.30
0.20
0.10
0.00
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 6PP Element:WS Result:Precipitation
Run:RUN 6PP Element:WS Result:Precipitation Loss
Run:RUN 6PP Element:WS Result:Outflow
Run:RUN 6PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 7** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.003 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.0024 | 79 |
| Brush | Good | D | 73 | 0.0006 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.26 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 28.41 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 185.4 | |
| Watercourse Slope, s (ft/ft) | 0.33 | |
| Average Velocity, V (ft/s) | 9.3 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.33 min.

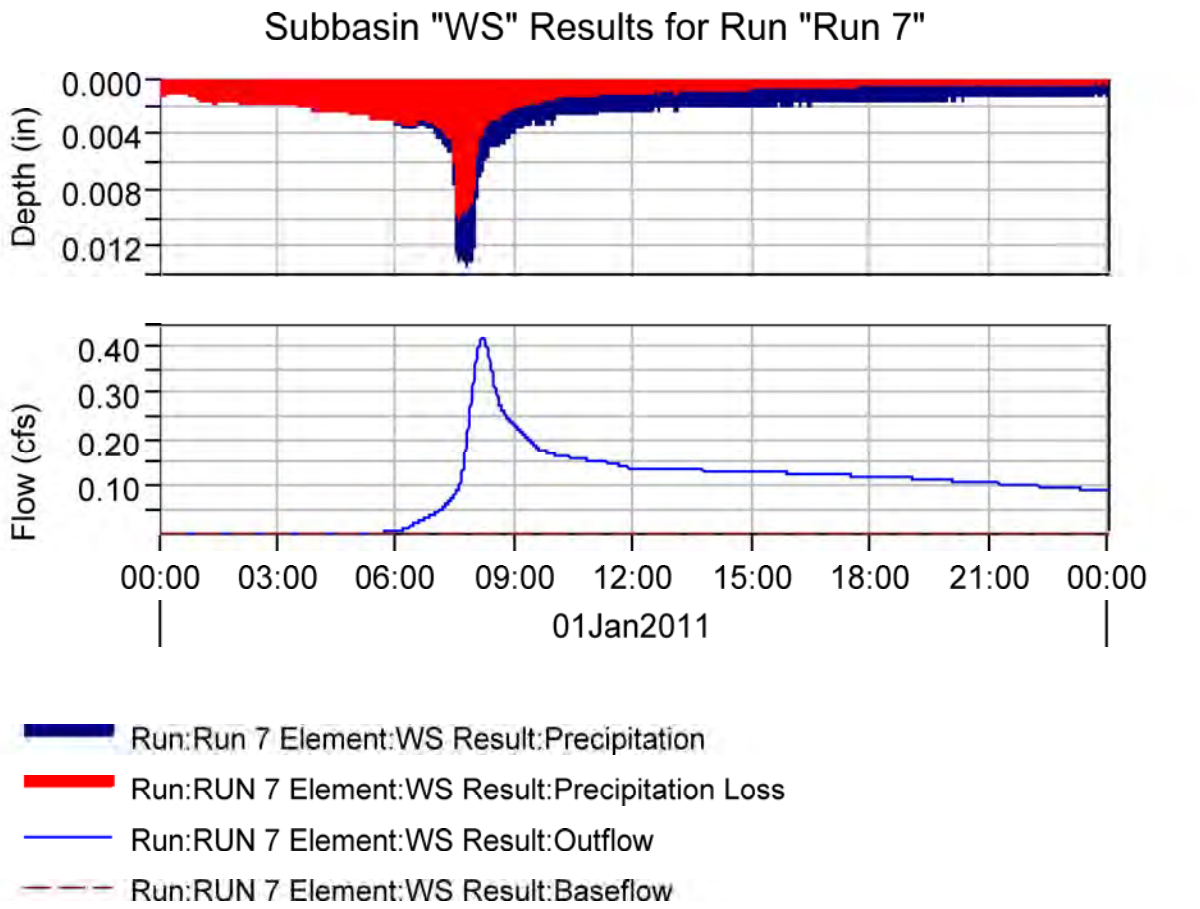
$$Tc = T_{AB} + T_{BC} = \boxed{28.74} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{17.24} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.91} \text{ min.}$$


Subbasin "WS" Results for Run "Run 7"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.40
0.30
0.20
0.10
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 7 Element:WS Result:Precipitation
Run:RUN 7 Element:WS Result:Precipitation Loss
Run:RUN 7 Element:WS Result:Outflow
Run:RUN 7 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 7** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.003 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.0006 | 20 |
| Brush | Good | D | 73 | 0.0024 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.26 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 28.41 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 185.4 | |
| Watercourse Slope, s (ft/ft) | 0.33 | |
| Average Velocity, V (ft/s) | 9.3 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.33 min.

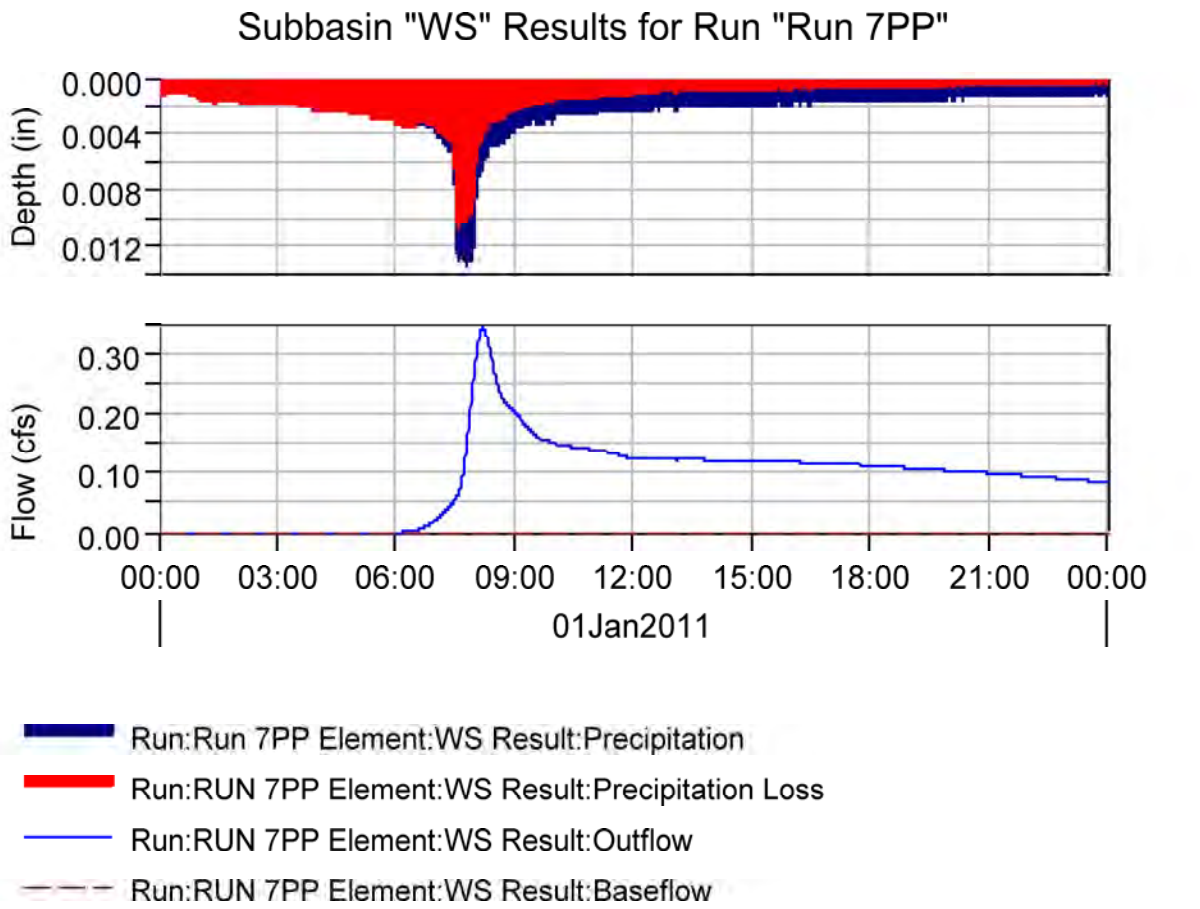
$$Tc = T_{AB} + T_{BC} = \boxed{28.74} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{17.24} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.91} \text{ min.}$$


Subbasin "WS" Results for Run "Run 7PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.30
0.20
0.10
0.00
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 7PP Element:WS Result:Precipitation
Run:RUN 7PP Element:WS Result:Precipitation Loss
Run:RUN 7PP Element:WS Result:Outflow
Run:RUN 7PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 8** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.00234 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00184 | 79 |
| Brush | Good | D | 73 | 0.00050 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.26 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 28.41 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 68.0 | |
| Watercourse Slope, s (ft/ft) | 0.36 | |
| Average Velocity, V (ft/s) | 9.7 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.12 min.

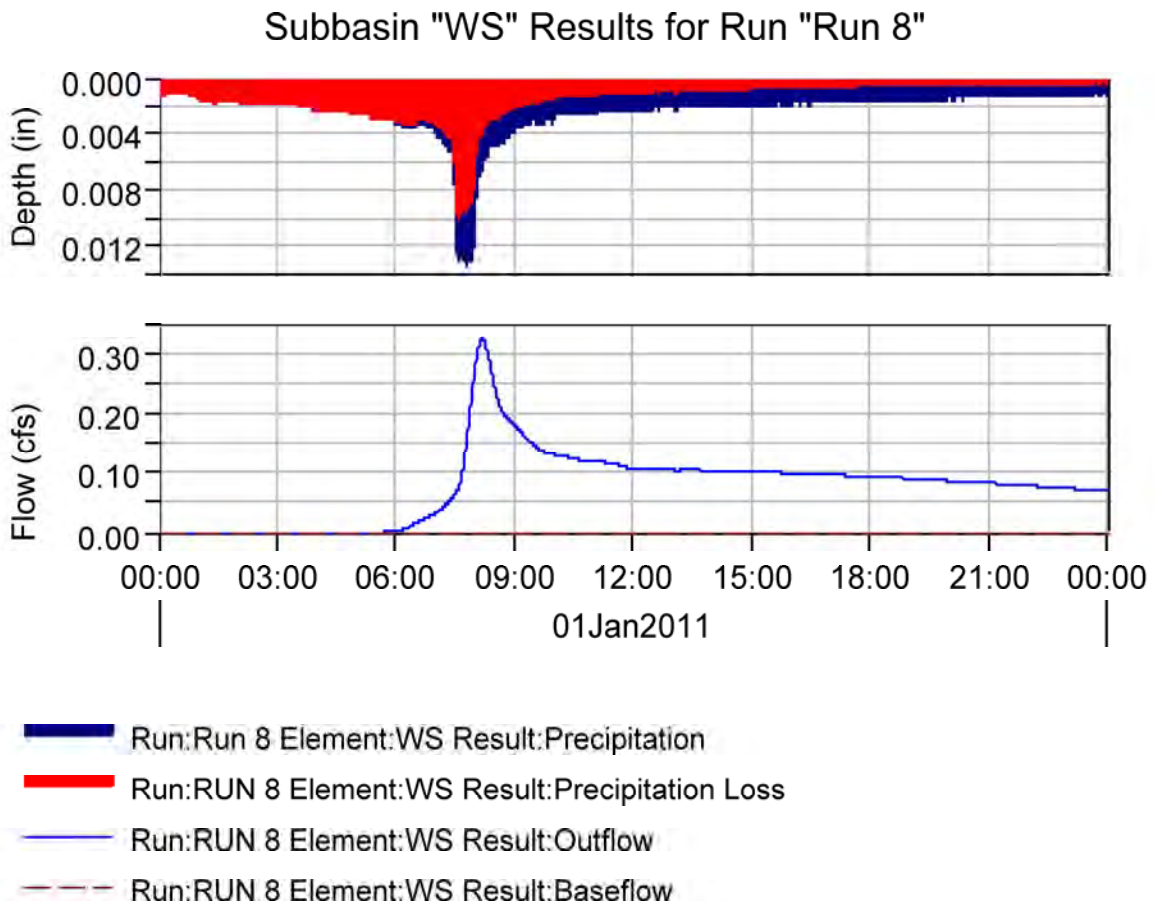
$$Tc = T_{AB} + T_{BC} = \boxed{28.53} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{17.12} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.90} \text{ min.}$$


Subbasin "WS" Results for Run "Run 8"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.30
0.20
0.10
0.00
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 8 Element:WS Result:Precipitation
Run:RUN 8 Element:WS Result:Precipitation Loss
Run:RUN 8 Element:WS Result:Outflow
Run:RUN 8 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 8** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.00234 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00046 | 20 |
| Brush | Good | D | 73 | 0.00188 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.26 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 28.41 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 68.0 | |
| Watercourse Slope, s (ft/ft) | 0.36 | |
| Average Velocity, V (ft/s) | 9.7 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.12 min.

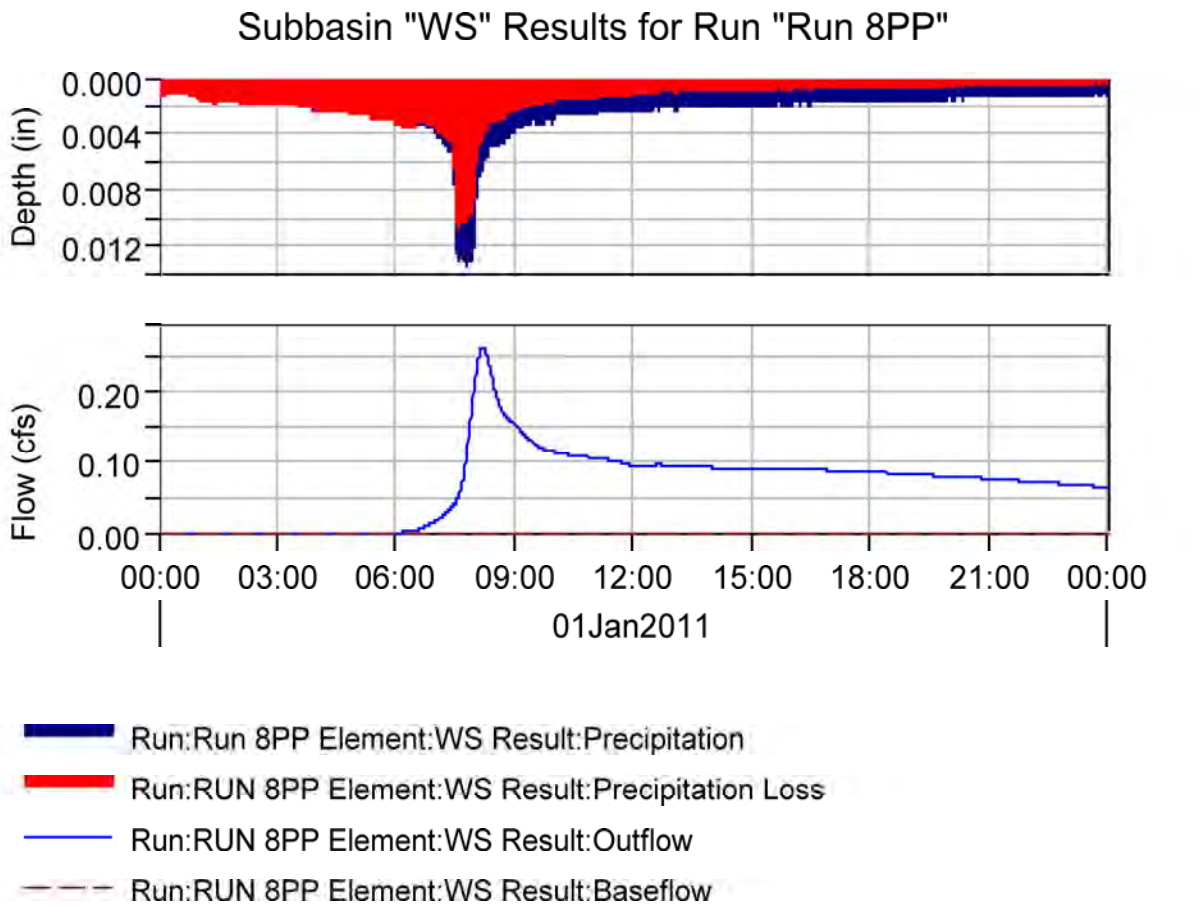
$$Tc = T_{AB} + T_{BC} = \boxed{28.53} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{17.12} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.90} \text{ min.}$$


Subbasin "WS" Results for Run "Run 8PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.20
0.10
0.00
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 8PP Element:WS Result:Precipitation
Run:RUN 8PP Element:WS Result:Precipitation Loss
Run:RUN 8PP Element:WS Result:Outflow
Run:RUN 8PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 9** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0139 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.01089 | 79 |
| Brush | Good | D | 73 | 0.00298 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.11 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 40.14 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 412.2 | |
| Watercourse Slope, s (ft/ft) | 0.31 | |
| Average Velocity, V (ft/s) | 9.0 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.76 min.

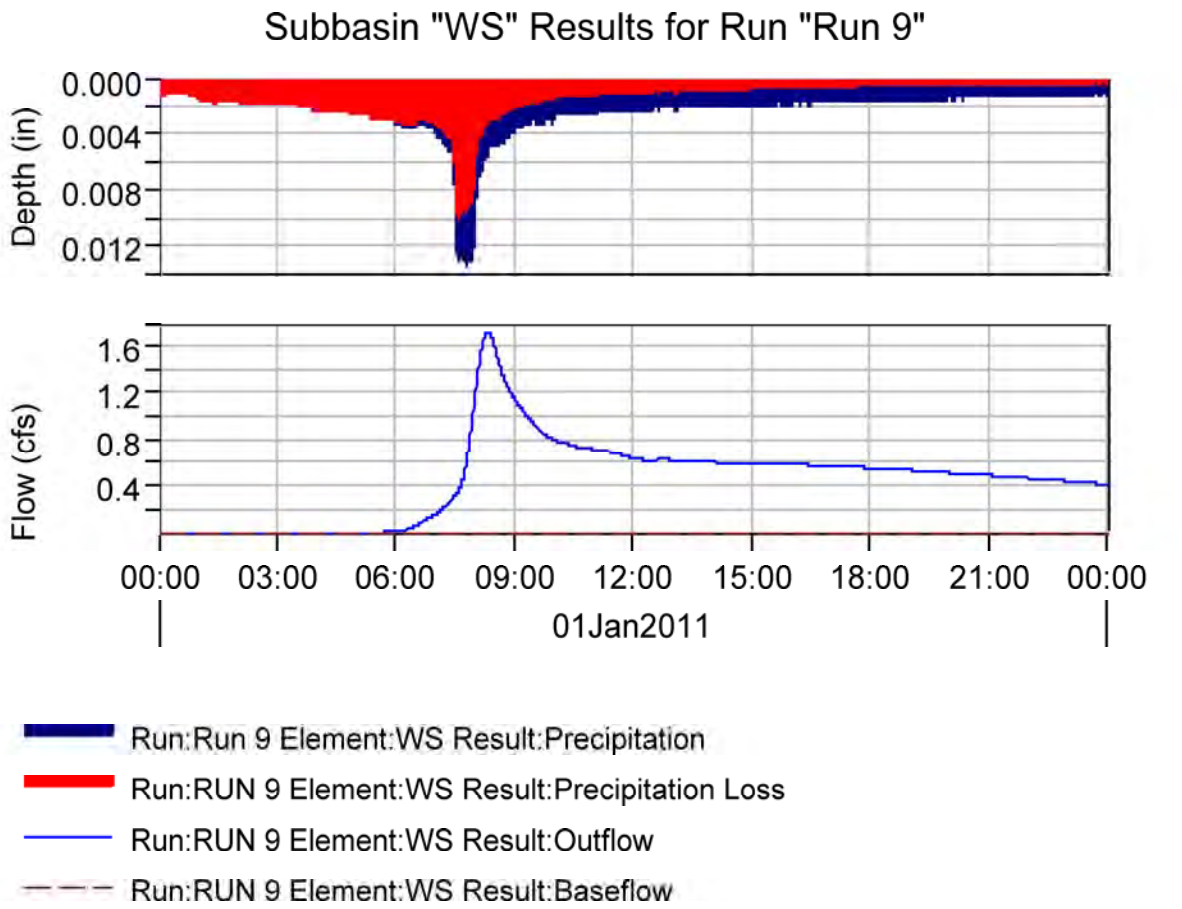
$$Tc = T_{AB} + T_{BC} = \boxed{40.90} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{24.54} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{2.72} \text{ min.}$$


Subbasin "WS" Results for Run "Run 9"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
1.6
1.2
0.8
0.4
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 9 Element:WS Result:Precipitation
Run:RUN 9 Element:WS Result:Precipitation Loss
Run:RUN 9 Element:WS Result:Outflow
Run:RUN 9 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 9** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0139 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00272 | 20 |
| Brush | Good | D | 73 | 0.01114 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.11 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 40.14 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 412.2 | |
| Watercourse Slope, s (ft/ft) | 0.31 | |
| Average Velocity, V (ft/s) | 9.0 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.76 min.

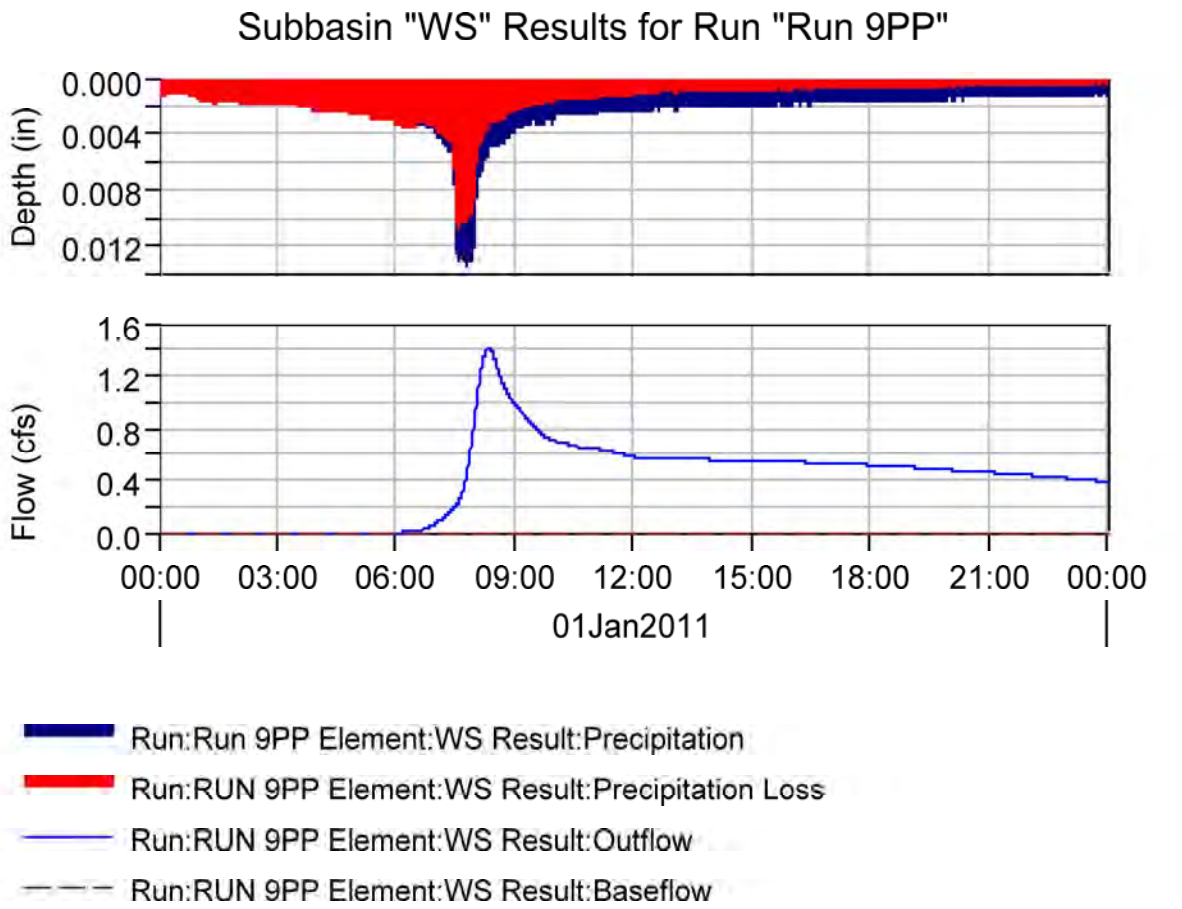
$$Tc = T_{AB} + T_{BC} = \boxed{40.90} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{24.54} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{2.72} \text{ min.}$$


Subbasin "WS" Results for Run "Run 9PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
1.6
1.2
0.8
0.4
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 9PP Element:WS Result:Precipitation
Run:RUN 9PP Element:WS Result:Precipitation Loss
Run:RUN 9PP Element:WS Result:Outflow
Run:RUN 9PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 10** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0075 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00592 | 79 |
| Brush | Good | D | 73 | 0.00162 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.23 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 29.80 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 137.3 | |
| Watercourse Slope, s (ft/ft) | 0.58 | |
| Average Velocity, V (ft/s) | 12.3 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.19 min.

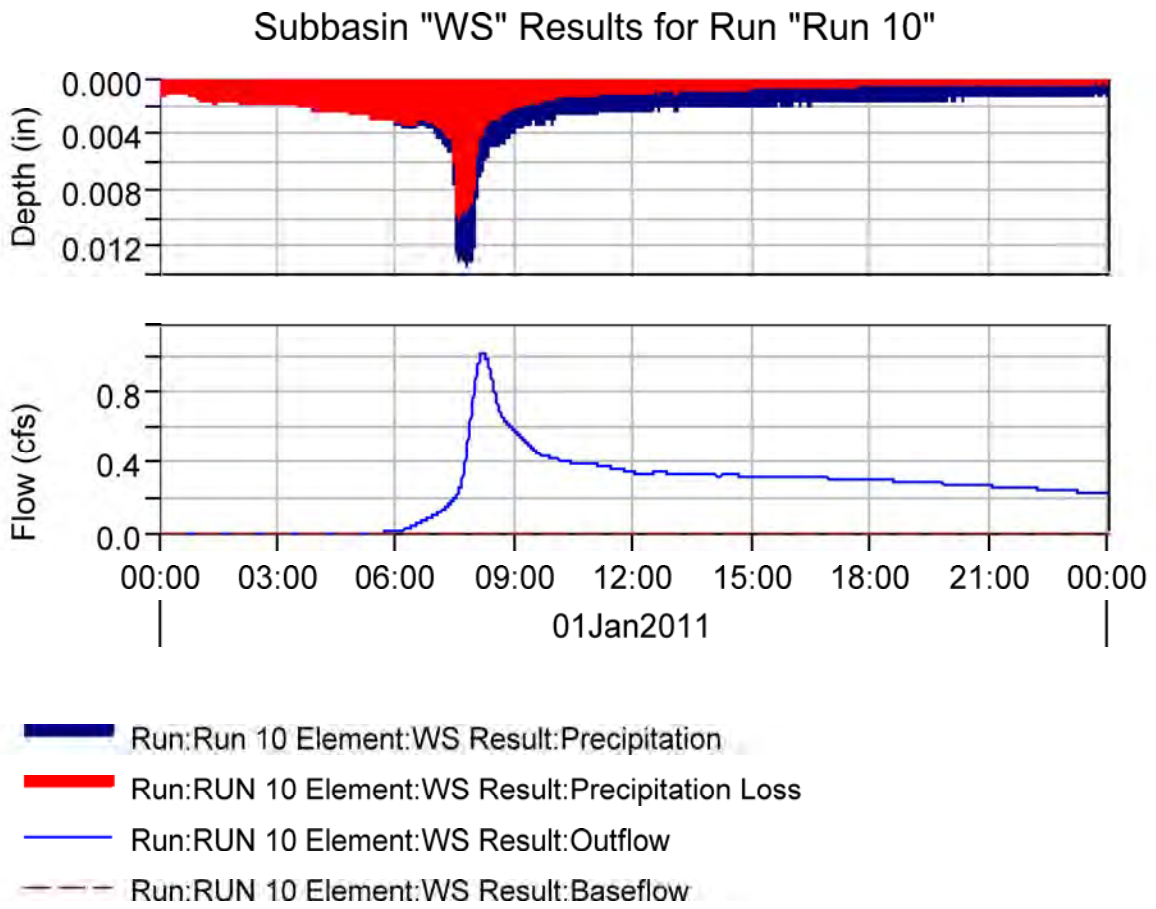
$$Tc = T_{AB} + T_{BC} = \boxed{29.99} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{17.99} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.99} \text{ min.}$$


Subbasin "WS" Results for Run "Run 10"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.8
0.4
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 10 Element:WS Result:Precipitation
Run:RUN 10 Element:WS Result:Precipitation Loss
Run:RUN 10 Element:WS Result:Outflow
Run:RUN 10 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 10** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0075 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00148 | 20 |
| Brush | Good | D | 73 | 0.00606 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.23 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 29.80 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 137.3 | |
| Watercourse Slope, s (ft/ft) | 0.58 | |
| Average Velocity, V (ft/s) | 12.3 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.19 min.

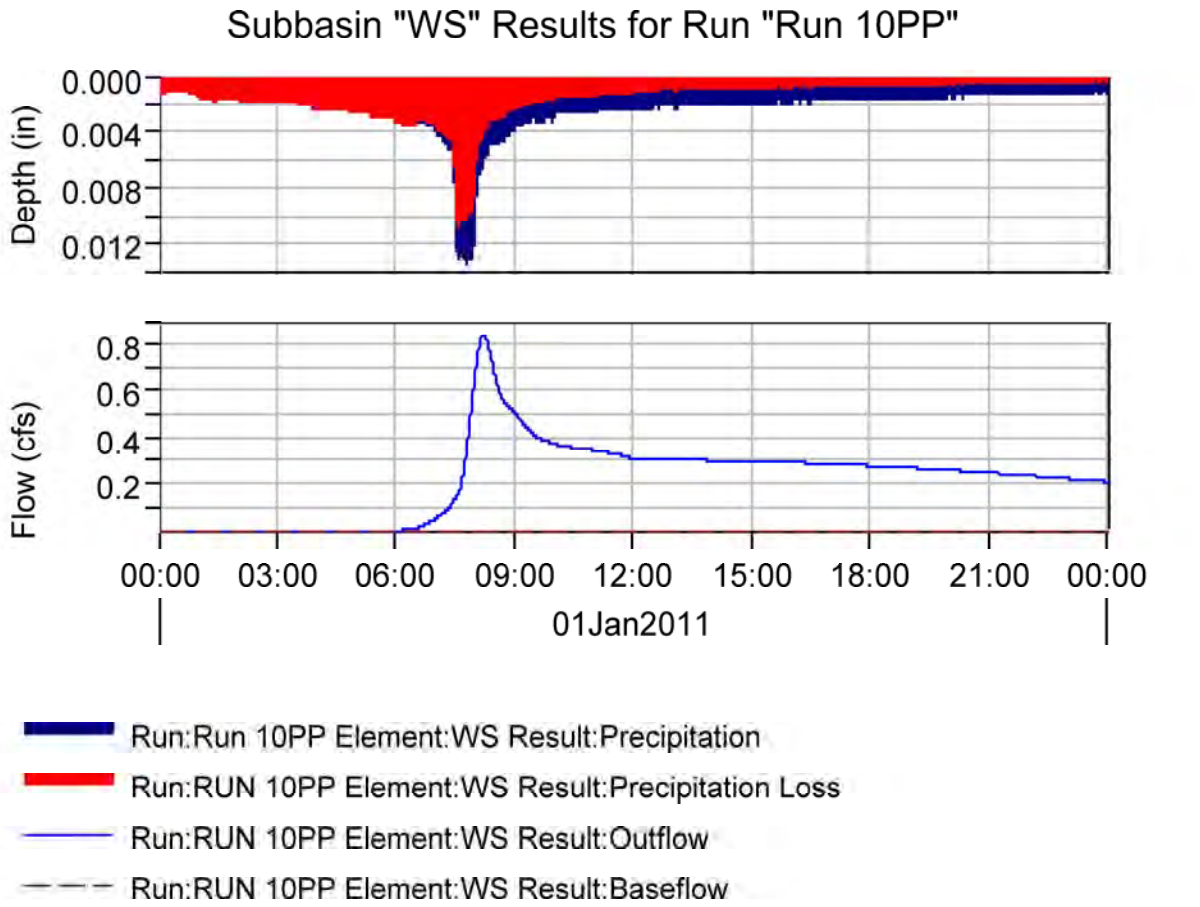
$$Tc = T_{AB} + T_{BC} = \boxed{29.99} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{17.99} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.99} \text{ min.}$$


Subbasin "WS" Results for Run "Run 10PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.8
0.6
0.4
0.2
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 10PP Element:WS Result:Precipitation
Run:RUN 10PP Element:WS Result:Precipitation Loss
Run:RUN 10PP Element:WS Result:Outflow
Run:RUN 10PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 11** **Pre-Project Conditions**

Watershed Characteristics

Area, A = 0.01006 $mi.^2$
Precipitation, P* = 3.30 in.

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.007902 | 79 |
| Brush | Good | D | 73 | 0.002159 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.31 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 26.78 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 284.0 | |
| Watercourse Slope, s (ft/ft) | 0.54 | |
| Average Velocity, V (ft/s) | 11.8 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.40 min.

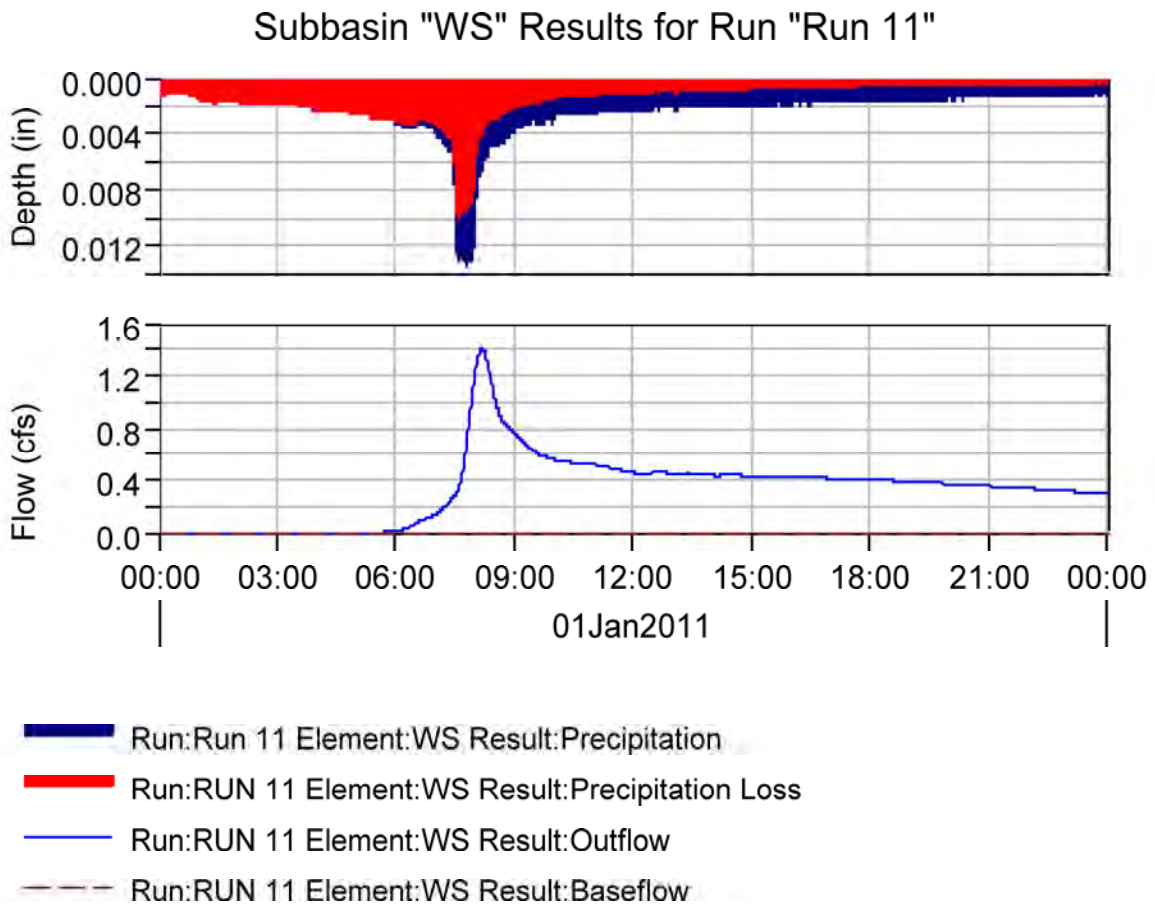
$$Tc = T_{AB} + T_{BC} = \boxed{27.18} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{16.31} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.81} \text{ min.}$$


Subbasin "WS" Results for Run "Run 11"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
1.6
1.2
0.8
0.4
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 11 Element:WS Result:Precipitation
Run:RUN 11 Element:WS Result:Precipitation Loss
Run:RUN 11 Element:WS Result:Outflow
Run:RUN 11 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 11** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.01006 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.001976 | 20 |
| Brush | Good | D | 73 | 0.008086 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB |
|---|---|
| Surface Description | Woods |
| Manning's *n* | 0.6 |
| Flow Length, L (ft) | 300 |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 |
| Land Slope, s (ft/ft) | 0.31 |

*Woods with average underbrush density.

* 2-yr., 24-hr rainfall from NOAA Atlas 14.

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 26.78 min.

Shallow Concentrated Flow

| Segment ID | BC |
|---|---|
| Surface Description | Unpaved |
| Flow Length, L (ft) | 284.0 |
| Watercourse Slope, s (ft/ft) | 0.54 |
| Average Velocity, V (ft/s) | 11.8 |

*For Unpaved, $V = 16.1345\ (s)^{0.5}$

Travel Time, $T_{BC} = L / 60V =$ 0.40 min.

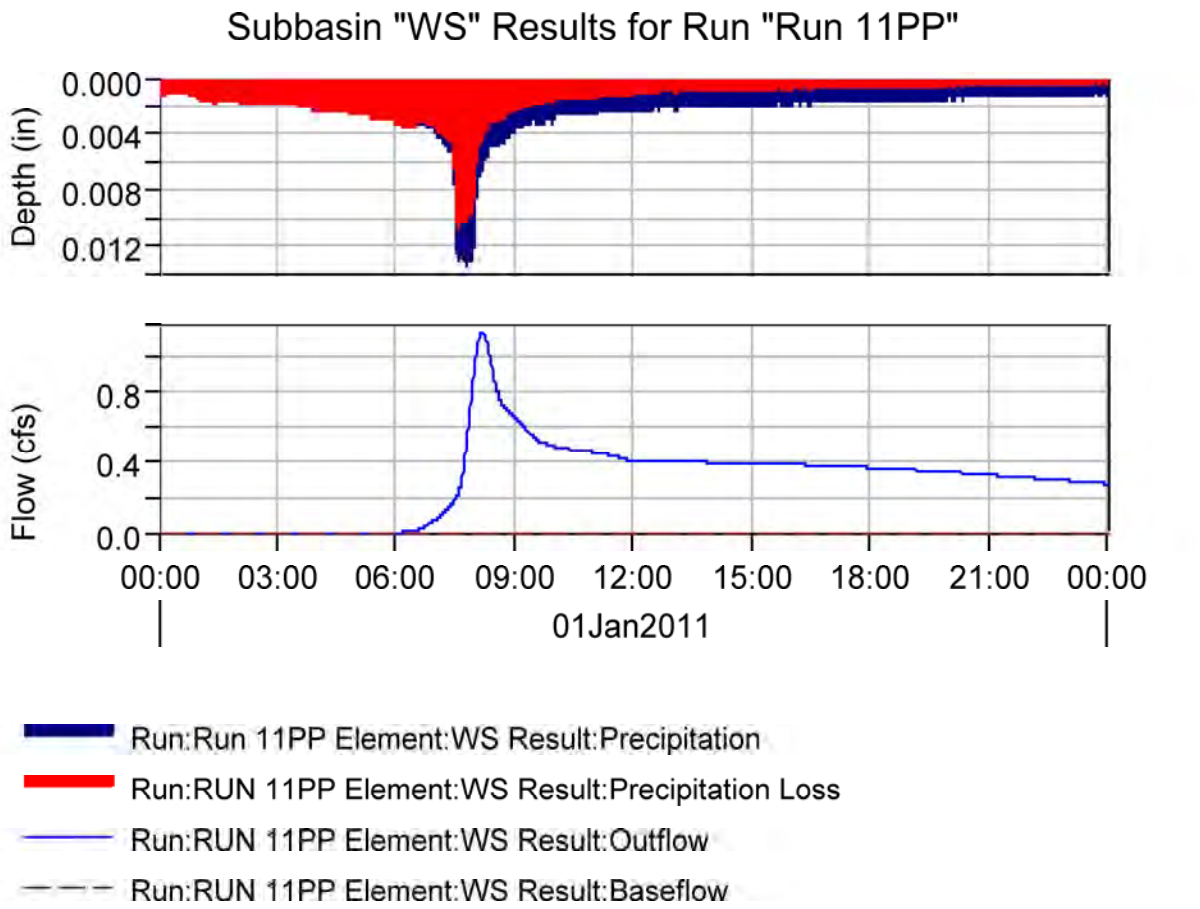
$$Tc = T_{AB} + T_{BC} = \boxed{27.18} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{16.31} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.81} \text{ min.}$$


Subbasin "WS" Results for Run "Run 11PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.8
0.4
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 11PP Element:WS Result:Precipitation
Run:RUN 11PP Element:WS Result:Precipitation Loss
Run:RUN 11PP Element:WS Result:Outflow
Run:RUN 11PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 12** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0047 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00367 | 79 |
| Brush | Good | D | 73 | 0.00100 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.41 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 23.85 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 141.8 | |
| Watercourse Slope, s (ft/ft) | 0.52 | |
| Average Velocity, V (ft/s) | 11.7 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.20 min.

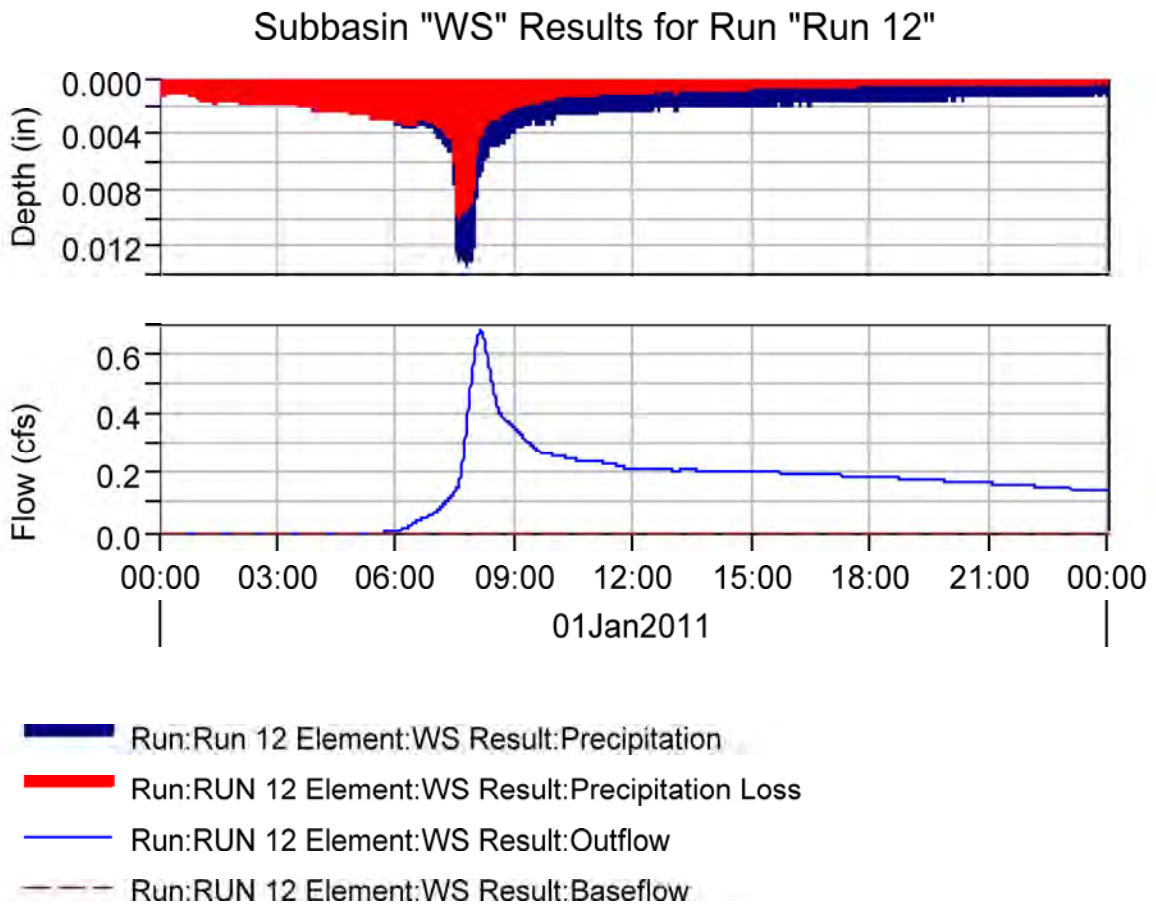
$$Tc = T_{AB} + T_{BC} = \boxed{24.06} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{14.43} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.60} \text{ min.}$$


Subbasin "WS" Results for Run "Run 12"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.6
0.4
0.2
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 12 Element:WS Result:Precipitation
Run:RUN 12 Element:WS Result:Precipitation Loss
Run:RUN 12 Element:WS Result:Outflow
Run:RUN 12 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 12** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0047 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00092 | 20 |
| Brush | Good | D | 73 | 0.00376 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.41 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 23.85 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 141.8 | |
| Watercourse Slope, s (ft/ft) | 0.52 | |
| Average Velocity, V (ft/s) | 11.7 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.20 min.

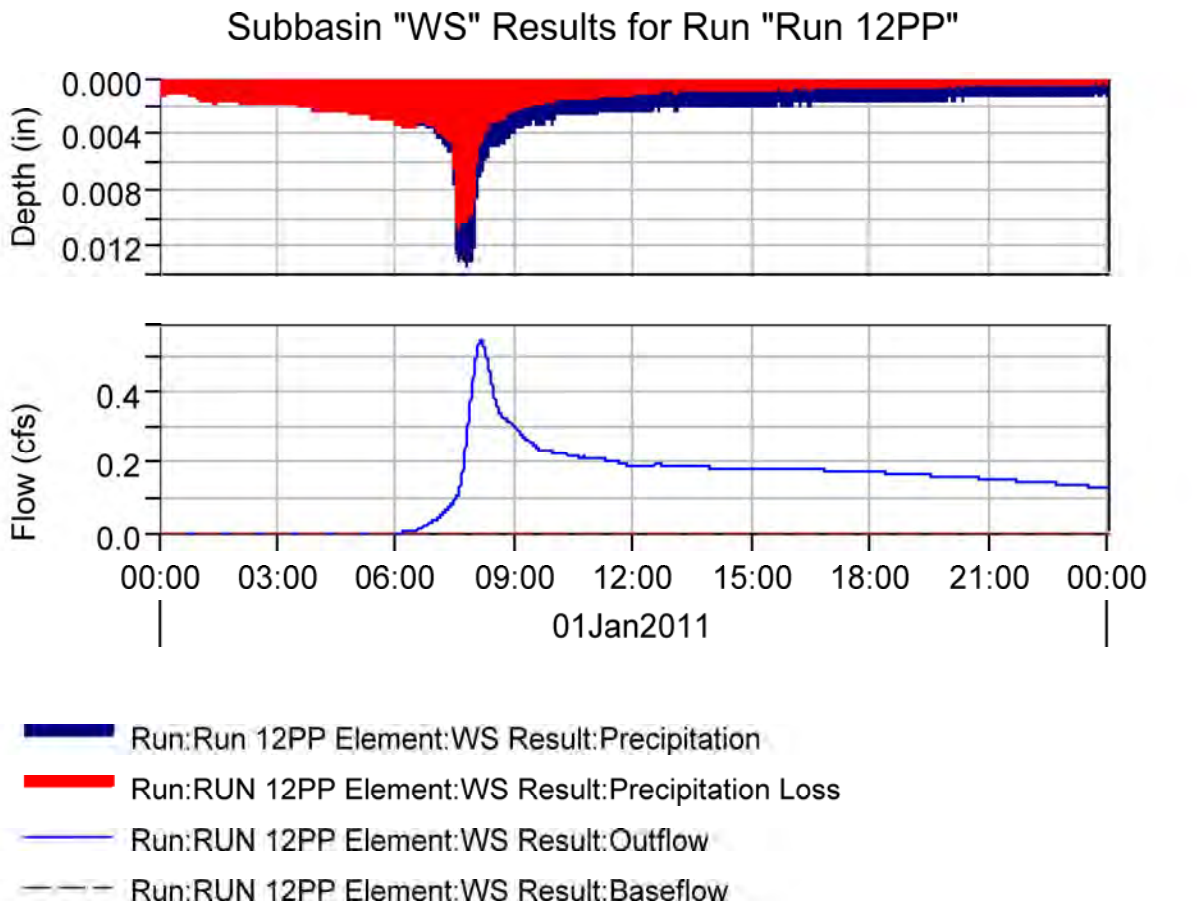
$$Tc = T_{AB} + T_{BC} = \boxed{24.06} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{14.43} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.60} \text{ min.}$$


Subbasin "WS" Results for Run "Run 12PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.4
0.2
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 12PP Element:WS Result:Precipitation
Run:RUN 12PP Element:WS Result:Precipitation Loss
Run:RUN 12PP Element:WS Result:Outflow
Run:RUN 12PP Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 13** **Pre-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0054 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00425 | 79 |
| Brush | Good | D | 73 | 0.00116 | 21 |

Area Weighted CN = 76.1

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.5 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 21.78 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 86.8 | |
| Watercourse Slope, s (ft/ft) | 0.71 | |
| Average Velocity, V (ft/s) | 13.6 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.11 min.

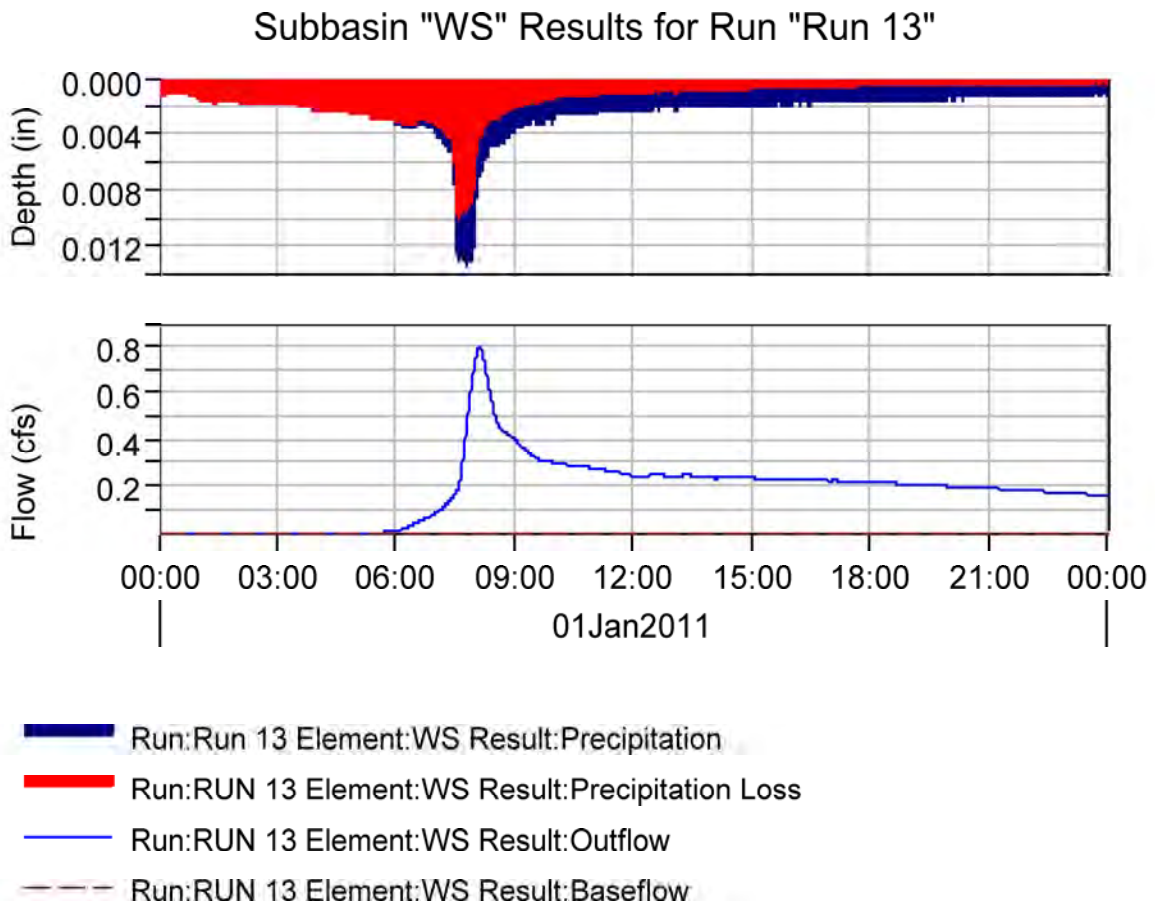
$$Tc = T_{AB} + T_{BC} = \boxed{21.89} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{13.13} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.46} \text{ min.}$$


Subbasin "WS" Results for Run "Run 13"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.8
0.6
0.4
0.2
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 13 Element:WS Result:Precipitation
Run:RUN 13 Element:WS Result:Precipitation Loss
Run:RUN 13 Element:WS Result:Outflow
Run:RUN 13 Element:WS Result:Baseflow

**Project Name:** UCSF - Mount Sutro
**Project Location:** San Francisco, CA
**Date:** 8/24/2011

## SCS Runoff, Peak Discharge and Synthetic Hydrograph

**Watershed 13** **Post-Project Conditions**

Watershed Characteristics

| | | |
|---|---|---|
| Area, A = | 0.0054 | $mi.^2$ |
| Precipitation, P* = | 3.30 | in. |

* 5-yr., 24-hr rainfall from NOAA Atlas 14.

Determination of SCS Runoff Curve Number, CN

| Cover Type | Hydrologic Condition | HSG | CN | Area ($mi.^2$) | % of Total |
|---|---|---|---|---|---|
| Woods | Good | D | 77 | 0.00106 | 20 |
| Brush | Good | D | 73 | 0.00435 | 80 |

Area Weighted CN = 73.8

Determination of Time of Concentration, Tc

Sheet Flow

| Segment ID | AB | |
|---|---|---|
| Surface Description | Woods | *Woods with average underbrush density. |
| Manning's *n* | 0.6 | |
| Flow Length, L (ft) | 300 | |
| 2-yr, 24-hr Rainfall, $P_2$ (in) | 2.58 | * 2-yr., 24-hr rainfall from NOAA Atlas 14. |
| Land Slope, s (ft/ft) | 0.5 | |

Travel Time, $T_{AB} = [(0.007)(n\ L)^{0.8} / (P_2^{0.5})(s^{0.4})] * 60 =$ 21.78 min.

Shallow Concentrated Flow

| Segment ID | BC | |
|---|---|---|
| Surface Description | Unpaved | |
| Flow Length, L (ft) | 86.8 | |
| Watercourse Slope, s (ft/ft) | 0.71 | |
| Average Velocity, V (ft/s) | 13.6 | *For Unpaved, $V = 16.1345\ (s)^{0.5}$ |

Travel Time, $T_{BC} = L / 60V =$ 0.11 min.

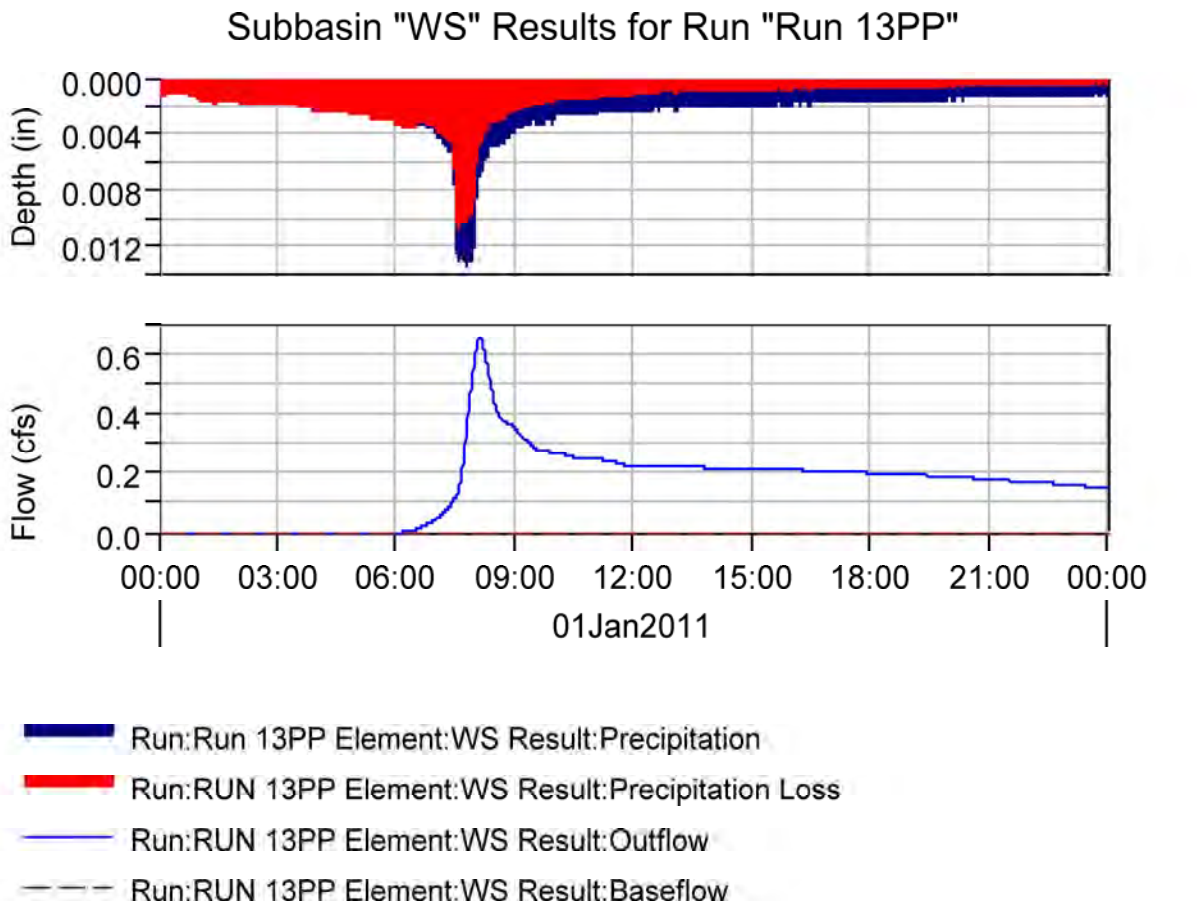
$$Tc = T_{AB} + T_{BC} = \boxed{21.89} \text{ min.}$$

Determination of Lag Time, $T_{lag}$

$$T_{Lag} = Tc * 0.6 = \boxed{13.13} \text{ min.}$$

Determination of Time Interval, dt

$$dt = (0.133 * Tc) / 2 = \boxed{1.46} \text{ min.}$$


Subbasin "WS" Results for Run "Run 13PP"
Depth (in)
0.000
0.004
0.008
0.012
Flow (cfs)
0.6
0.4
0.2
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2011
Run:Run 13PP Element:WS Result:Precipitation
Run:RUN 13PP Element:WS Result:Precipitation Loss
Run:RUN 13PP Element:WS Result:Outflow
Run:RUN 13PP Element:WS Result:Baseflow

# APPENDIX I

NOISE ASSESSMENT

21 July 2010

Diane Wong
UCSF Campus Planning
3333 California Street, Suite 11
San Francisco, CA 94143
Email: dwong@planning.ucsf.edu

Subject: UCSF Parnassus Equipment Noise Study DRAFT
CSA Project No. 10-0042

Dear Diane:

On May 27, 2010, we met with UCSF staff, Paul Franke, on site to conduct acoustical measurements of the existing stationary mechanical equipment serving various buildings on the UCSF Parnassus Campus. We conducted short-term and week-long measurements at three locations (identified as 3, 4, and 5) established in previous acoustical studies. In addition, two measurement locations (identified as T1 and T2) were selected at the western edge of the Surge Building parking lot. Please refer to Figure 1 for a map of the locations. The short-term measurements were used to identify any equipment as a primary noise source that could be mitigated to reduce the overall noise levels at the nearest property lines. The long-term measurements were conducted to monitor the average noise levels based on varying levels of equipment operation capacity. The measurement locations and noise comparison analysis are based on the Campus Noise Abatement Study provided by Smith, Fause, McDonald, Inc. in 1998[1].

We have also evaluated the proposed thinning of the eucalyptus trees (Demonstration Projection 2) in the Mount Sutro Open Space Reserve. These trees populate the hillside separating the various equipment areas from the nearest residences located on Edgewood Avenue.

The purpose of this report is to summarize and compare current and previous noise levels at the Parnassus Campus to noise criteria standards used by UCSF. This report will also provide preliminary recommendations to further reduce equipment noise and analyze the noise environment associated with the proposed tree thinning project.

**E□ECU□I□E SUMM□R□**

□ Modifications to existing equipment and new equipment installed since the 1998 Noise Study have reduced the overall noise levels measured from the Central Plant to the nearest residential property lines

[1] Smith, Fause, McDonald, Inc., Campus Noise Abatement Study Phase II: Assessment of Existing Noise Levels, , Modeling and Mitigation Measures, Southeast Campus Edge, February 24, 1998

 The existing mechanical equipment meets the City's updated Noise Ordinance criteria when using the minimum measured noise levels as the ambient, and meets the City's criteria based on the minimum ambient noise levels with no equipment operating. However, the current noise level is three dBA[2] above the City's former nighttime criteria at the nearest property line measurement locations

 No single set of equipment cycled on and off demonstrated a change in the overall noise levels at the nearest residential property lines

 Existing eucalyptus trees provides a line-of-sight buffer from the existing equipment which provides some high-frequency noise reduction; further analysis would be needed to quantify the acoustical difference for the proposed tree thinning project

**CRI ERI**

At the time of the 1998 Smith, Fause, McDonald report, the San Francisco Noise Ordinance required that fixed equipment not exceed noise levels of 55 dBA between 7 A.M. and 10 P.M. and 50 dBA between 10 P.M. and 7 A.M. at the nearest residential property line. Based on the prior study, UCSF adopted 50 dBA as the goal for any new equipment. This noise goal is still in effect for all new Parnassus projects.

The San Francisco Noise Ordinance was updated in 2008. The current Noise Ordinance states that for Commercial Property Lines, "No person shall produce, or allow to be produced by any machine or device, a noise level more than eight dBA above the local ambient at any point outside of the property plane." Per the Ordinance, noise level measurements are to be taken not less than four feet above the ground, and protected from wind by the use of a windscreen on the microphone.

While it is not possible to measure ambient noise levels without the UCSF operating equipment, we would expect the lowest hourly ambient noise level to be 45 dBA, based on additional measurements taken at other nearby locations. Using an adjusted baseline of 45 dBA, the noise criterion as determined by the new Noise Ordinance would therefore be 53 dBA along the residential property line when measured at five feet above grade.

The existing UCSF equipment operation could be considered part of the existing ambient noise environment. Therefore, at five feet above grade, along the site's property line, the quietest hourly average noise level was measured to be 53 dBA at both Locations 3 and 4. Using San Francisco's updated 2008 Noise Ordinance criteria the maximum allowable threshold would be 61 dBA when measured at five feet above grade at the property line.

With regard to human perception of increases in sound levels expressed in dBA, a change of 1 dBA is generally not perceivable excluding controlled conditions and pure tones. Outside of controlled

[2] dBA  A-weighted sound pressure level (or noise level) represents the noisiness or loudness of a sound by weighting the amplitudes of various acoustical frequencies to correspond more closely with human hearing. A-weighting is specified by the U.S. EPA, OSHA, Caltrans, and others for use in noise measurements.

laboratory conditions, the average human ear barely perceives a change of 3 dBA. A change of 5 dBA generally fosters a noticeable change in human response and an increase of 10 dBA is subjectively heard as a doubling of loudness.

**ME□SUREME□□ SUMM□R□**

*Short-Term Measurements*

On May 27, we performed short-term measurements at three designated locations (identified as Locations 3, 4, and 5 in Figure 1) while equipment was cycled on and off. Measurements were conducted at nighttime when the ambient noise environment is quietest and when the capacity restraints on the ventilation equipment are minimized. The nearest residences are located on Edgewood Avenue, just east of UCSF's property line. The three measurement locations were the same locations established in the 1998 Smith, Fause, McDonald report, which we understand were selected due to their proximity to the equipment.

The purpose of the short-term measurements was to identify any single pieces of equipment that could be considered primary noise sources. Due to hospital and laboratory use and operation during these night-time measurements, not all equipment was cycled off. The measurements at all three locations did not fluctuate by more than one dBA, signifying that no single piece of equipment appears to be the dominant noise source. At Locations 3 and 4 we measured 53 dBA and at Location 5 we measured 48 dBA for each operation condition. The various operation conditions were as follows:

1. Power Plant: Rooftop Cooling Towers turned off

2. Power Plant: 2 of 3 rooftop pumps turned off

3. LPPI: Telecom equipment room exhaust fan turned off

4. Medical Science Building: Rooftop Fume Hood □23 turned off

5. Moffit Hospital: Rooftop Cooling Towers turned off

6. Moffit Hospital: Rooftop Exhaust Fans turned off

7. Long Hospital: Rooftop Chiller and Cooling Towers turned off

Although the dBA noise level did not change for each operation condition, we observed reduced noise levels at certain frequencies when specific equipment was cycled off. Reducing the noise generated by these types of equipment could help reduce the perceived loudness of the equipment at noise-sensitive areas. Figures 2 through 4 show the spectral noise levels for the measurements with the identified equipment turned off, as compared to the typical operating condition, which includes all equipment in standard operation. These graphs show the spectral composition by plotting the noise level (dB) at each third-octave frequency band (Hz), and are examples of where cycling the equipment demonstrated a noticeable difference in measured noise level.

In Figure 2, with the Power Plant cooling towers turned off, we observed four dB of reduction at the 125-Hz third-octave band at Location 3.

In Figure 3, with two of the three Power Plant pumps turned off, we observed two dB of reduction at the 200-Hz and 250-Hz third-octave bands at Location 5.

In Figure 4, with the Moffit Hospital exhaust fans turned off, we observed two dB of reduction at the 125-Hz and 250-Hz third octave band at Location 3.

A comparison of these measurements to the 1998 Smith, Fause, McDonald results indicates that the overall noise level generated by the campus has decreased. At Location 3, the noise level with all equipment operating has decreased from 56 dBA to 53 dBA, and at Location 5, the noise level decreased from 52 dBA to 48 dBA. Although the cumulative noise level still exceeds 50 dBA, this reduced noise level indicates that new equipment installed since 1998 meets the UCSF goal of 50 dBA (otherwise, the cumulative noise level would have remained the same or increased).

*Long-Term Measurements*

Between May 27 and June 2, we conducted long-term continuous measurements at Locations 3 and 5 for one week[3]. The long-term measurement meters were installed at an elevation of 12 feet above grade on trees or poles so that they would be out of reach. During simultaneous measurements with the meters at five feet above-grade, we found an increase of two to three dB at a height of 12 feet due to the increased exposure to the campus equipment. Over the week-long measurement, the lowest average noise level for the long-term measurement at Location 3 was 55 dBA and at Location 5 was 51 dBA (which correspond to 53 dBA and 48 dBA, respectively, at five feet above grade), which meets the current San Francisco Noise Ordinance criteria of 53 dBA as noted under the criteria section above.

Over the week-long measurement period, the minimum noise levels, as characterized by the L90[4] noise level, were between 55 and 59 dBA at Location 3 and between 51 and 54 dBA at Location 5. Figure 5 shows the time-based plot of the L90 noise levels at the two locations. The fluctuations in noise levels are mostly due to increased equipment loads during daytime hours, as well as some contribution from non-stationary noise sources, such as parking and loading activities on the UCSF site.

*Tree Replacement Analysis*

We conducted two short-term simultaneous measurements to determine the noise buffering that occurs with the existing eucalyptus trees, which cover most of the hillside separating the UCSF campus mechanical equipment from the nearest residences. Although trees are typically considered to have a

[3] The long-term meter at Location 4 had a malfunction and thus did not generate usable data. As indicated above, the short-term measurement results are nearly identical between Locations 3 and 4.

[4] L90 – The sound level in dBA that was equaled or exceeded 90 percent of the time.

negligible effect as a sound barrier, the purpose of this analysis was to quantify the noise reduction provided by the dense grove of existing eucalyptus trees.

The two measurement locations, shown as T1 and T2 on Figure 1, are at the west edge of the Surge Building parking lot and are an equal distance of approximately 250 feet from the power plant. Location T1 had a clear line-of-sight to the power plant; Location T2 was shielded by approximately 75 feet of eucalyptus trees. We measured 57 dBA with the trees at T2 and 59 dBA at T1 without the buffering from the trees. Figure 6 indicates the spectral plot of the two measurement locations.

The increase between the two measurements is in the higher frequencies (i.e., above 2-kHz). We observed the high-frequency water noise of the cooling towers (the nearest equipment at 250 feet from measurement location) to be more audible without the buffering from the trees. With the proposed tree thinning and removal project, the change in noise level would likely increase in areas such as Location 3, where there are currently over 200 feet of eucalyptus trees separating the residential property line from the nearest equipment.

The proposed tree thinning and replacement project could potentially increase the noise level at the nearest residences, depending on the area of trees to be removed.

ANALYSIS AND RECOMMENDATIONS

*□□uipment Mitigation*

With a stationary noise level of 53 dBA measured at five feet above grade at the nearest residential property line, the UCSF campus meets the current San Francisco Noise Ordinance. However, the existing equipment exceeds the former Ordinance criteria.

The results of the 1998 Smith, Fause, McDonald Noise Study indicated that the noise level with all mechanical equipment was 56 dBA at Location 3. Since the 1998 Noise Study, this reduction of noise was the result of modifications to existing equipment and installation of new quieter equipment.

In 2005, Charles M. Salter Associates conducted a noise measurement program for the Parnassus Seismic Replacement Building.[5] As part of this study, 55 dBA was measured at the nearest residential property line, approximately equal to Location 4, with all equipment operating during the nighttime hours. Based on our nighttime measurement results of 53 dBA during the week-long measurement (shown in Figure 5), we can estimate that the equipment noise levels have reduced by approximately two dBA since 2005 at Location 4.To reduce the equipment noise levels to meet either the former San Francisco Ordinance noise limit of 50 dBA, or the current San Francisco Ordinance noise limit of 53 dBA (based on an estimated ambient with no equipment operating), a series of mitigation measures should be incorporated to identify the subsequent noisiest equipment. Based on our most recent measurements, we have identified specific types of equipment that could be considered the noisiest. Equipment mitigation could consist of localized barriers or screenwalls, extended ductwork or baffles, or

[5] Charles M. Salter Associates, PSSRB Environmental Noise Study, June 9, 2005.

replacement of specific equipment. Following is a list of the identified equipment with recommended mitigation schemes:

**Power Plant Cooling □owers□**We measured a noise level of 80 dBA with the cooling towers turned on versus 64 dBA with the cooling towers turned off at a distance of one foot. To reduce the low-frequency noise at the nearest residential property line (see the measurement plot in Figure 2), the reduced nighttime loads could allow for operating the interior tower so that the outer tower is off and acts as an acoustical barrier.

**Power Plant Pumps□**We measured a close-up noise level of 76 dBA with the three pumps turned on and 73 dBA with two of the three pumps turned off. To reduce the low-frequency noise at the property line (see Figure 3), screen walls or barriers should be considered.

**Moffit □uilding Cooling □owers□**We understand that in October of 2010, the pumps are to incorporate a variable speed drive (VSD) and the "fill" material is to be a sound-absorbing polyester product.

**Moffit □uilding E□haust □ans□**We understand that one of these fans (the largest one an "ETO fan") is significantly oversized for its use. Slowing the fan speed to 1,750 from 3,600 rpm could reduce the noise levels at the low and mid-frequency bands; however, slowing the fan speed could also increase the low-frequency noise levels. Replacing the fan with equipment properly sized for its use would be recommended to reduce the low and mid-frequency noise levels (see the measurement plot in Figure 4).

**LPPI E□haust □an□**With this fan turned off we observed no change in noise level at the residential property line measurement locations; however, the fan is located near an entrance to the LPPI building and an outside sitting area. The fan casing rattles and is 81 dBA at a distance of one foot. We understand the fan is significantly oversized and blowing air in the wrong direction. Replacing the fan with equipment properly sized for its use should be considered to reduce the noise to the outdoor pedestrian environment.

**Medical Science □uilding fume hood □□□□**With this fan turned off we observed no change at the residential property line measurement locations; however, the fan is located between 100 and 200 feet from hospital patient rooms with direct line-of-sight. We measured a noise level of 85 dBA close to the fan and would estimate the noise level at the patient rooms to be approximately 60 dBA, which could be audible with the windows open. Rooftop equipment that is damaged or has reached the end of its expected useful life should be prioritized for replacement.

* * *

This completes our summary of the equipment noise study for the UCSF Parnassus campus. Should you have any questions, please do not hesitate to call.

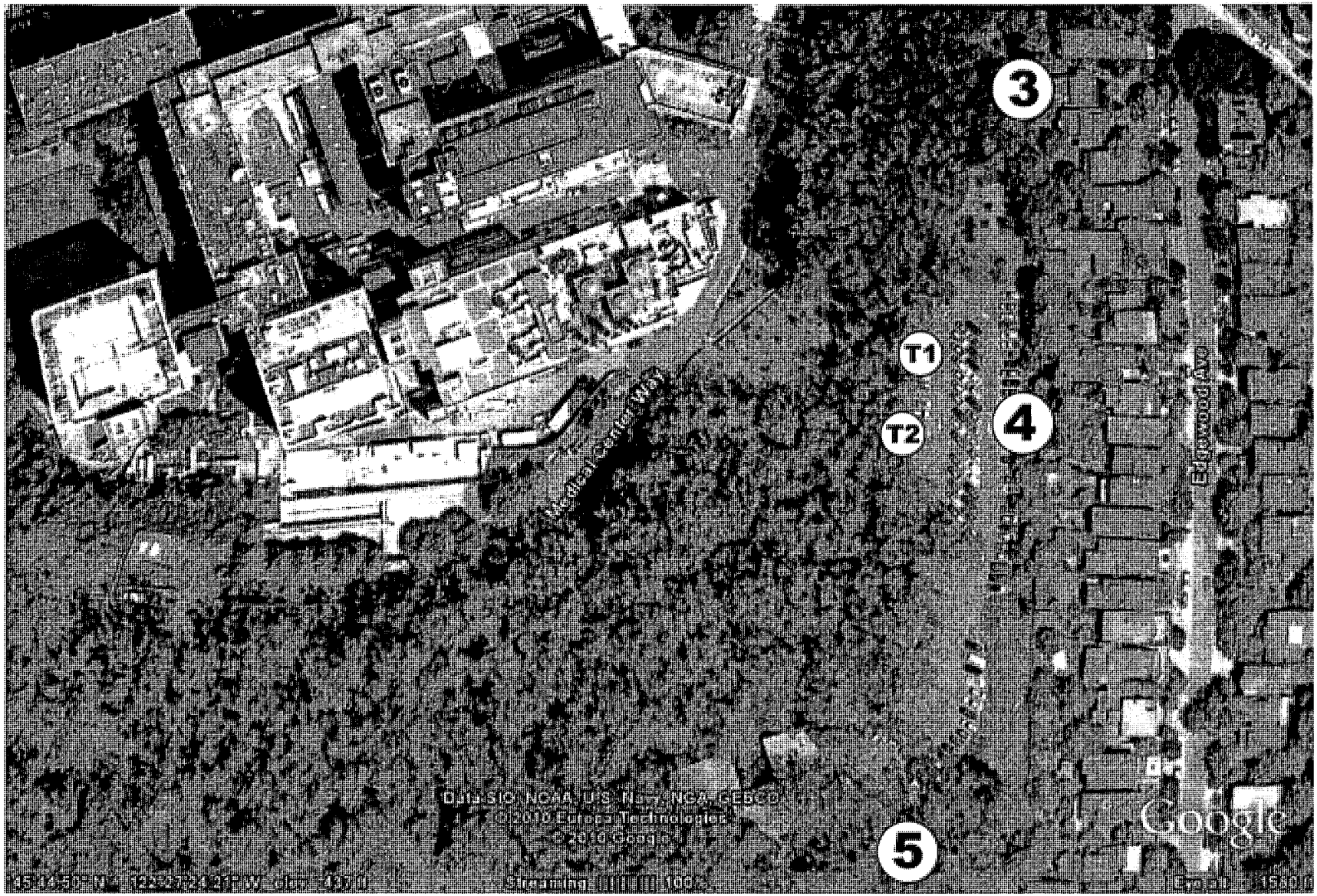
Sincerely,

CHARLES M. SALTER ASSOCIATES, INC.

Peter K. Holst, P.E., LEED AP
Principal Consultant

| | SF Noise Ordinance (dBA)nighttime | Test Location T1 | Test Location T2 | Test Location 3 | Test Location 4 | Test Location 5 |
|---|---|---|---|---|---|---|
| 1998 | 50 | NA | NA | 56 | | 52 |
| 2005 | 50 | NA | NA | | 55 | |
| 2010 | 53/61 | NA | NA | 53 | 53 | 48 |

Charles M Salter Associates Inc 130 Sutter Street San Francisco California 94104 Tel: 415 397 0442 Fax: 415 397 0454



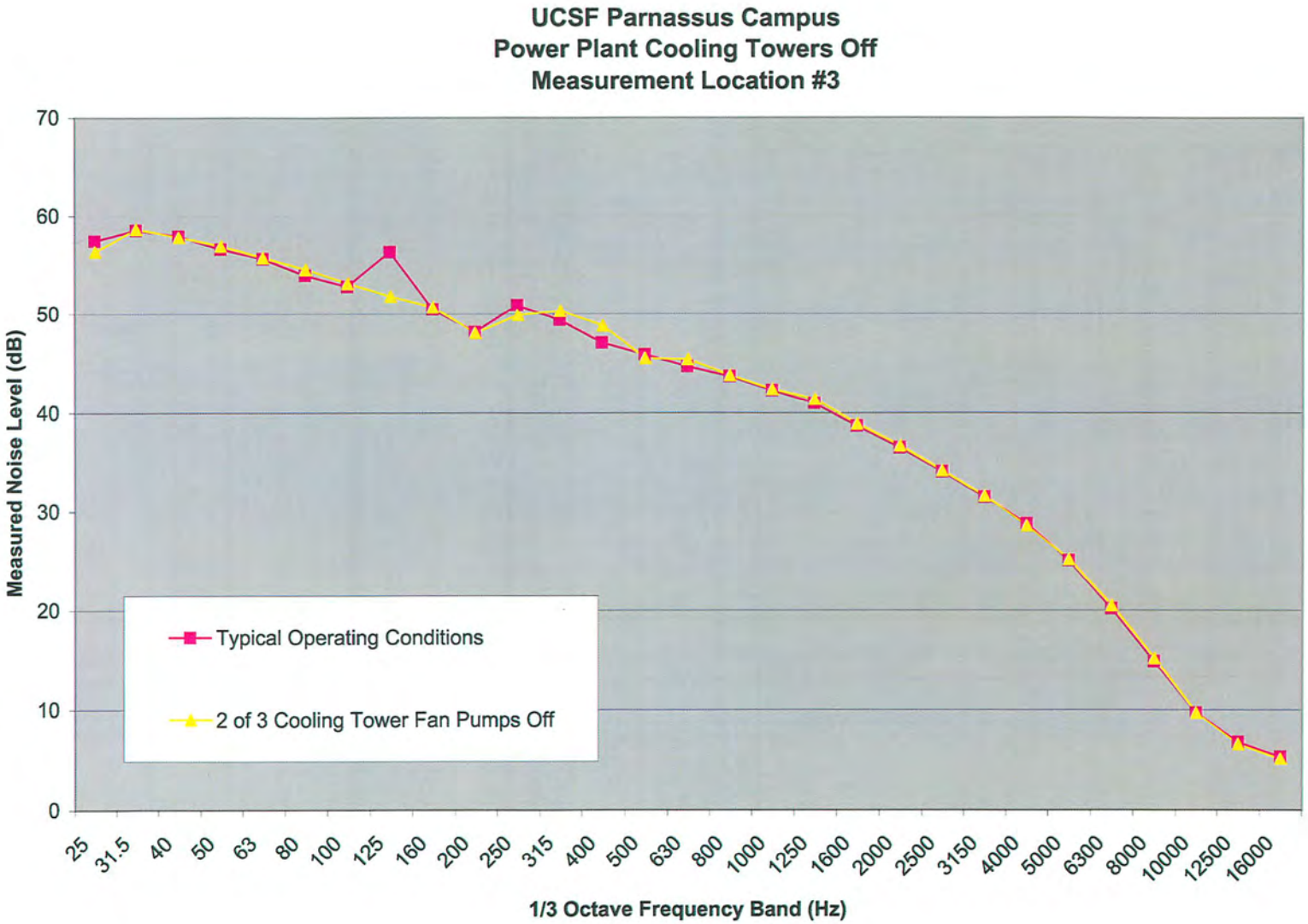

© 2010
CHARLES M. SALTER ASSOCIATES, INC.
FOR ACOUSTICAL DESIGN INFORMATION ONLY

# UCSF PARNASSUS CAMPUS MEASUREMENT LOCATIONS

## FIGURE 1

| CSA # | PKH |
|---|---|
| 10-0042 | 07.06.10 |

Charles M Salter Associates Inc 130 Sutter Street San Francisco California 94104 Tel: 415 397 0442 Fax: 415 397 0454




© 2010
CHARLES M. SALTER ASSOCIATES, INC.
FOR ACOUSTICAL DESIGN INFORMATION ONLY

# UCSF PARNASSUS CAMPUS EQUIPMENT NOISE STUDY

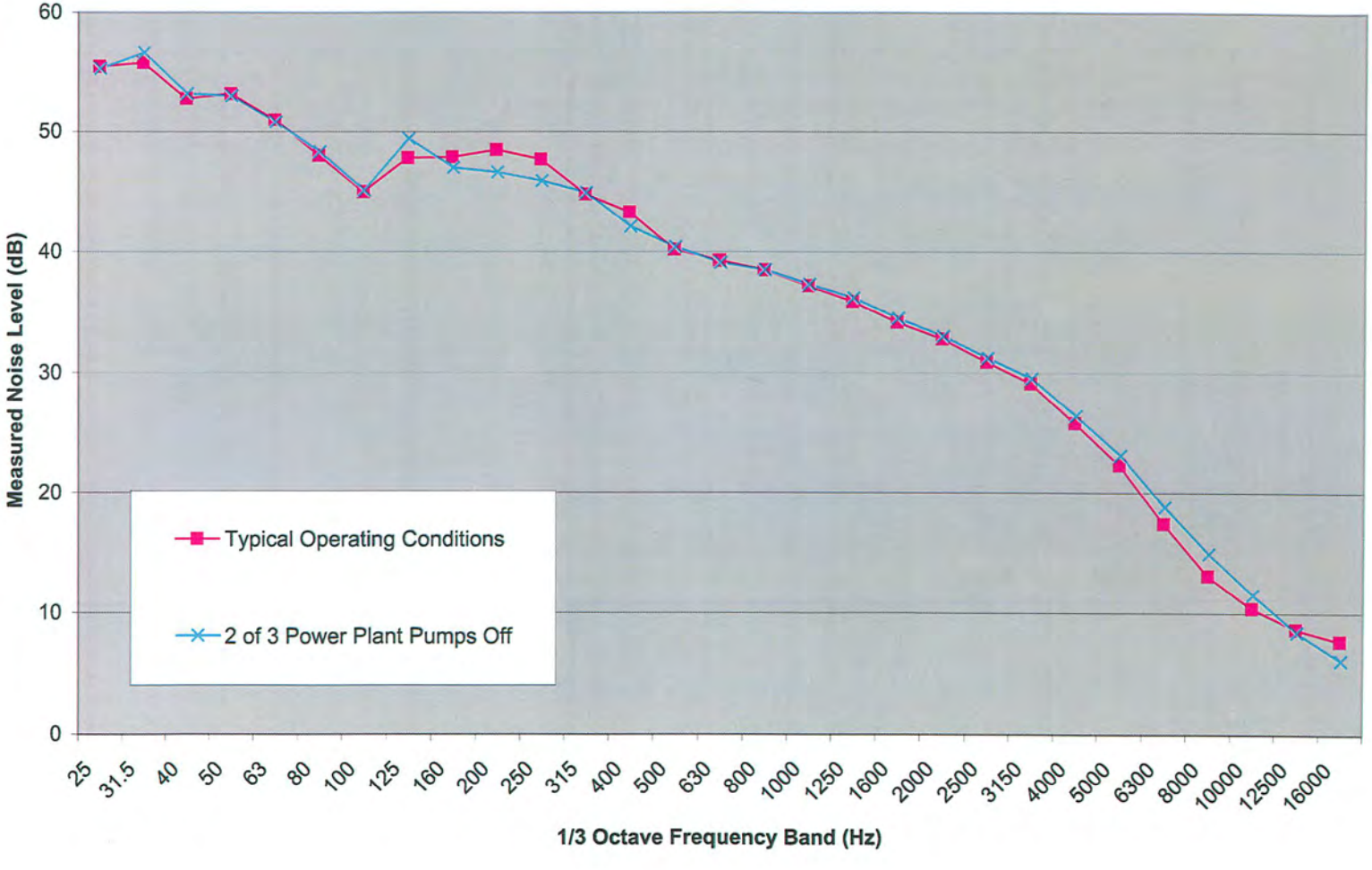
## FIGURE 2

CSA # 10-0042

PKH 07.06.10

Charles M Salter Associates Inc 130 Sutter Street San Francisco California 94104 Tel: 415 397 0442 Fax: 415 397 0454

**UCSF Parnassus Campus**
**Power Plant Pumps Off**
**Measurement Location #5**




© 2010
CHARLES M. SALTER ASSOCIATES, INC.
FOR ACOUSTICAL DESIGN INFORMATION ONLY

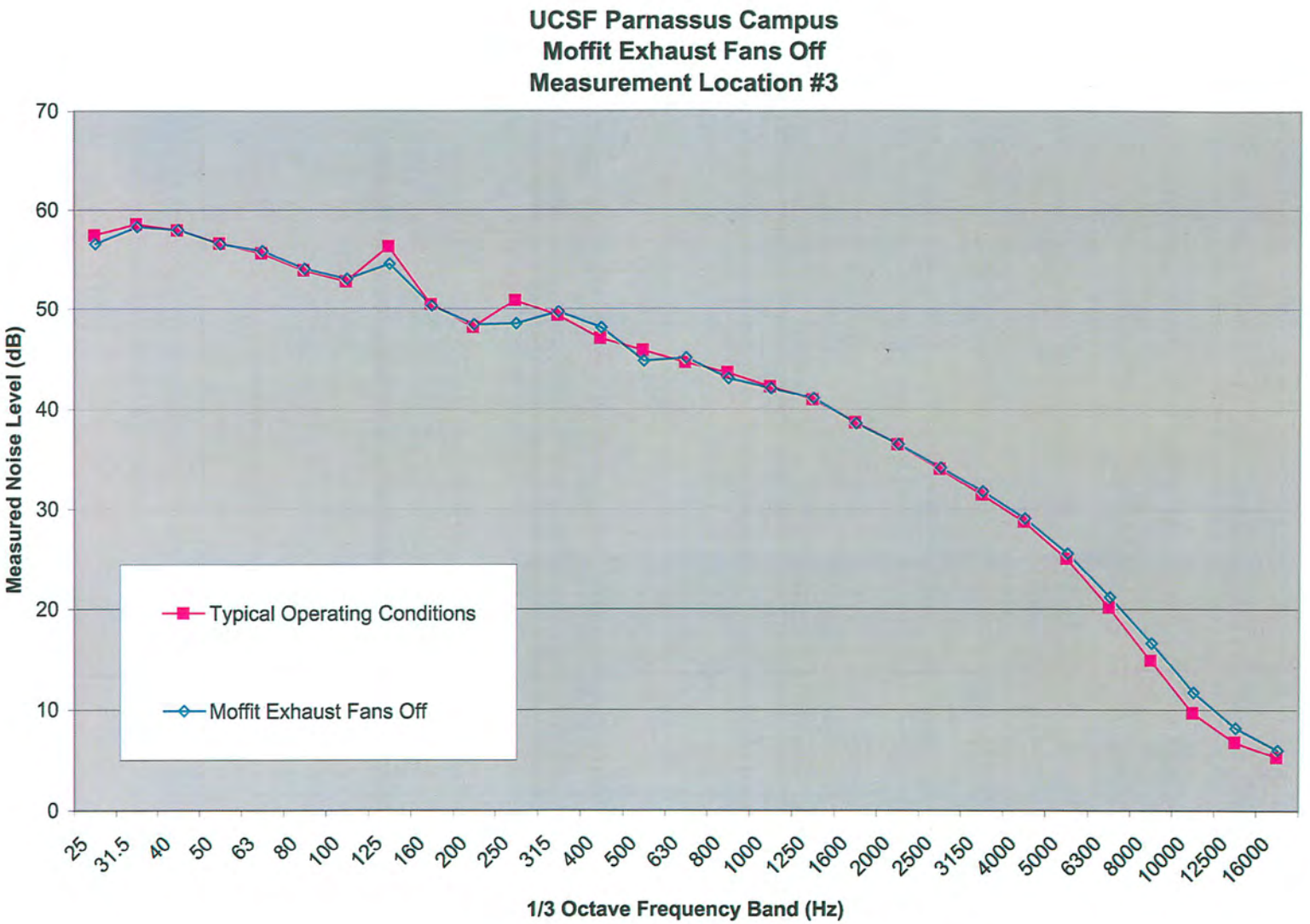
# UCSF PARNASSUS CAMPUS EQUIPMENT NOISE STUDY

## FIGURE 3

CSA # 10-0042

PKH 07.06.10

Charles M Salter Associates Inc 130 Sutter Street San Francisco California 94104 Tel: 415 397 0442 Fax: 415 397 0454




© 2010
CHARLES M. SALTER ASSOCIATES, INC.
FOR ACOUSTICAL DESIGN INFORMATION ONLY

# UCSF PARNASSUS CAMPUS EQUIPMENT NOISE STUDY

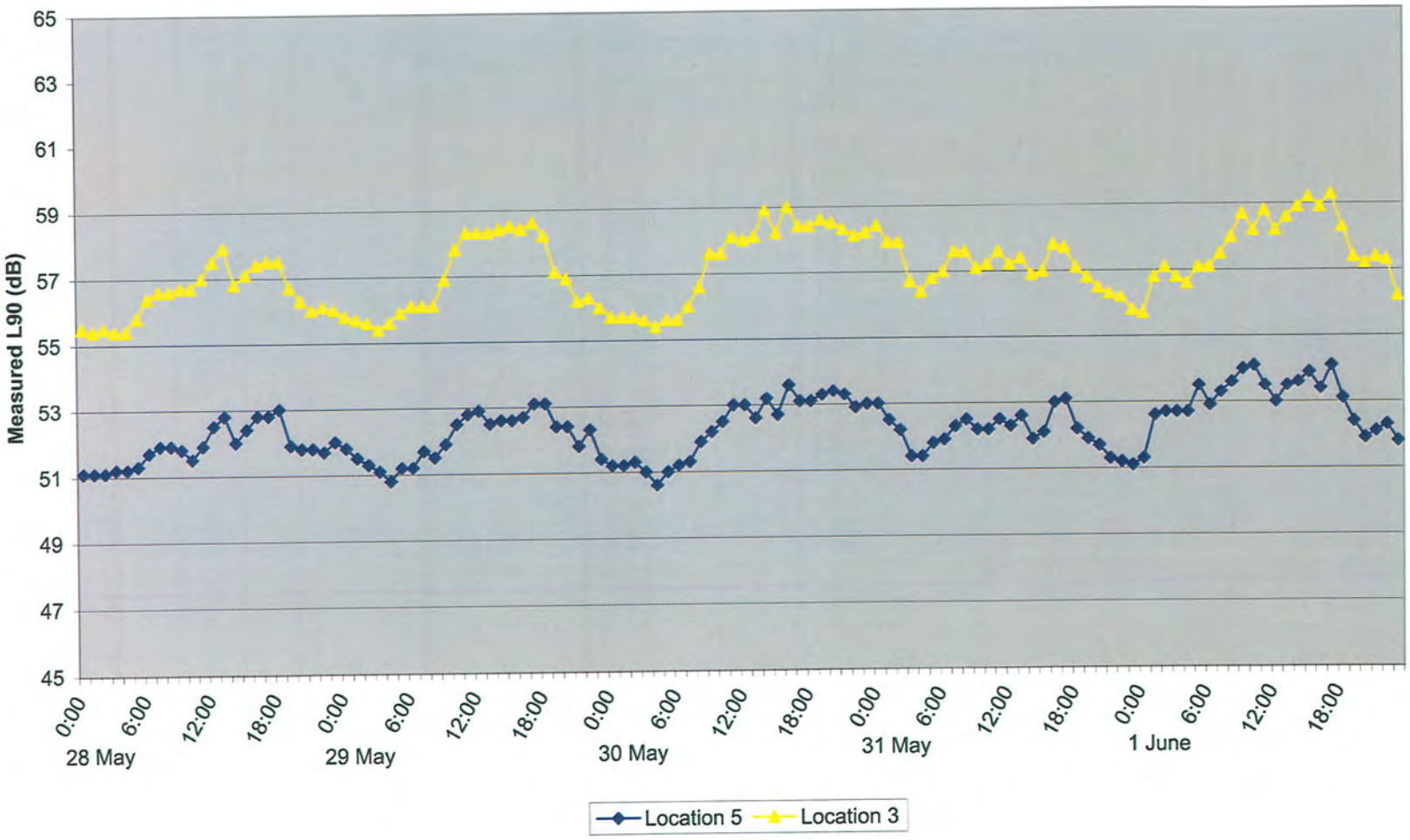
## FIGURE 4

CSA # 10-0042

PKH 07.06.10

Charles M Salter Associates Inc 130 Sutter Street San Francisco California 94104 Tel: 415 397 0442 Fax: 415 397 0454

**UCSF Parnassus Campus**
**28 May through 1 June 2010**
**Minimum Property Line Hourly Noise Levels**




© 2010
CHARLES M. SALTER ASSOCIATES, INC.
FOR ACOUSTICAL DESIGN INFORMATION ONLY

# UCSF PARNASSUS CAMPUS EQUIPMENT NOISE STUDY

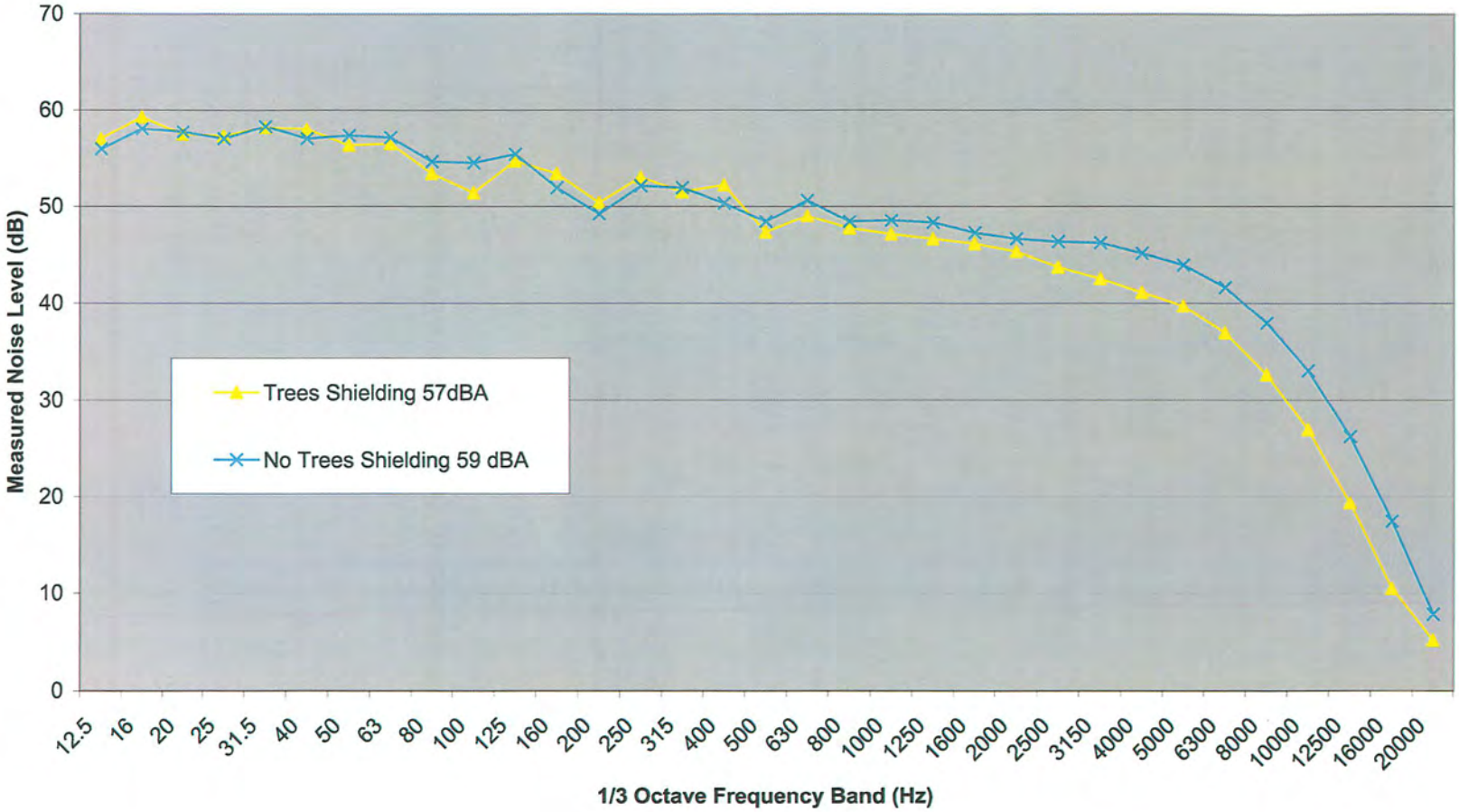
## FIGURE 5

CSA # 10-0042

PKH 07.06.10

Charles M Salter Associates Inc 130 Sutter Street San Francisco California 94104 Tel 415 397 0442 Fax 415 397 0454

**UCSF Parnassus Campus**
**Tree Removal Measurements**
**Approximately 75' Of Trees**




© 2010
CHARLES M. SALTER ASSOCIATES, INC.
FOR ACOUSTICAL DESIGN INFORMATION ONLY

# UCSF PARNASSUS CAMPUS EQUIPMENT NOISE STUDY

## FIGURE 6

CSA # 10-0042

PKH 07.06.10

# APPENDIX J

WIND DATA

## Figure J-1

## Station 1 Windrose

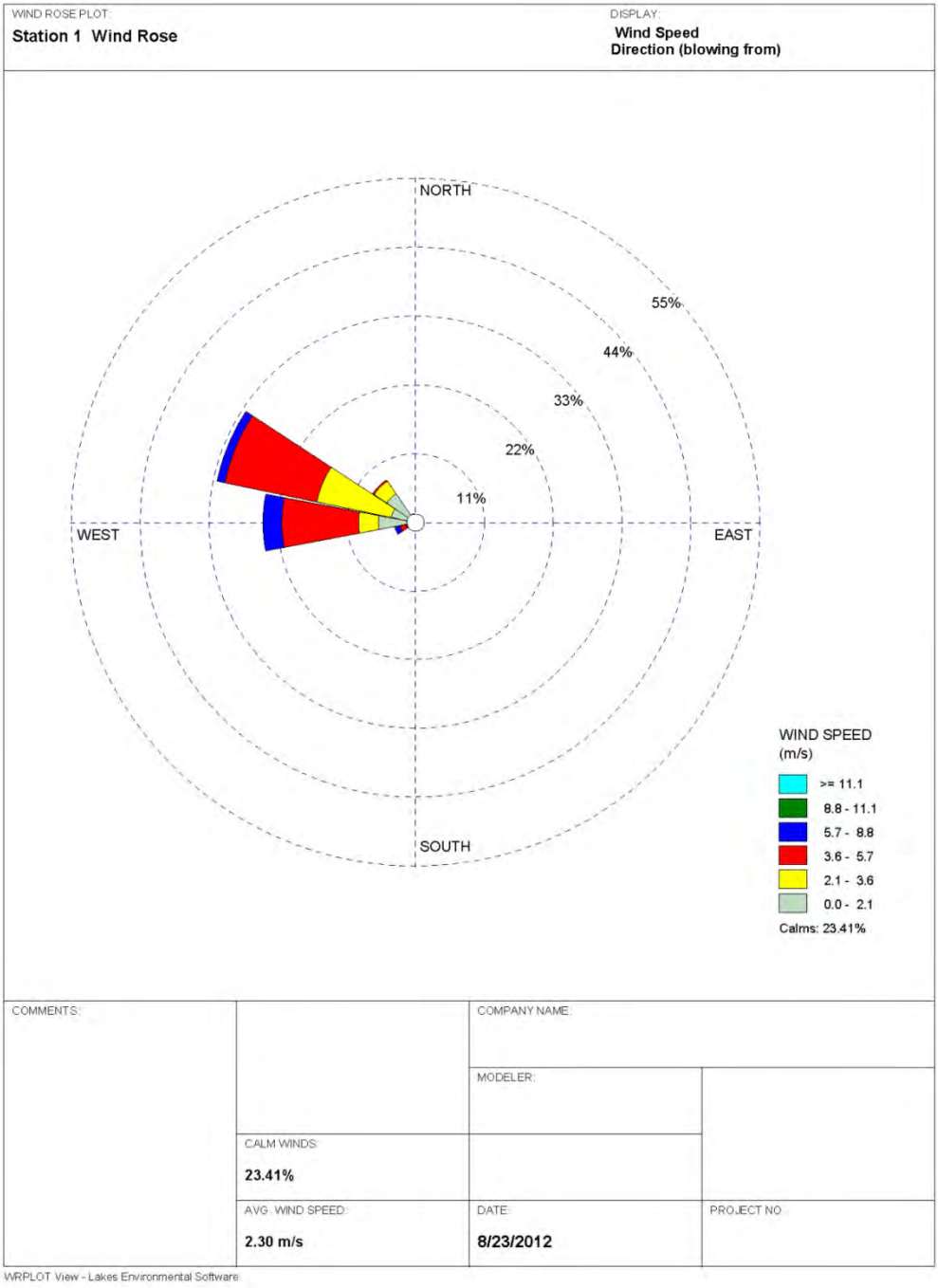


**Table J-1 Station 1 Wind Speed and Direction Frequency Distribution Table**

| | | Wind Speed Classes (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Wind Direction** | **0.0 - 2.1** | **2.1 - 3.6** | **3.6 - 5.7** | **5.7 - 8.8** | **8.8 - 11.1** | **>= 11.1** | **Total** |
| **1** | **348.75 - 11.25** | 0.95% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.95% |
| **2** | **11.25 - 33.75** | 0.63% | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.65% |
| **3** | **33.75 - 56.25** | 0.74% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.74% |
| **4** | **56.25 - 78.75** | 0.82% | 0.07% | 0.00% | 0.00% | 0.00% | 0.00% | 0.89% |
| **5** | **78.75 - 101.25** | 0.52% | 0.04% | 0.00% | 0.00% | 0.00% | 0.00% | 0.56% |
| **6** | **101.25 - 123.75** | 0.76% | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.78% |
| **7** | **123.75 - 146.25** | 0.50% | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.52% |
| **8** | **146.25 - 168.75** | 0.48% | 0.04% | 0.00% | 0.00% | 0.00% | 0.00% | 0.52% |
| **9** | **168.75 - 191.25** | 0.11% | 0.09% | 0.00% | 0.00% | 0.00% | 0.00% | 0.20% |
| **10** | **191.25 - 213.75** | 0.24% | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.26% |
| **11** | **213.75 - 236.25** | 0.41% | 0.13% | 0.30% | 0.07% | 0.00% | 0.00% | 0.91% |
| **12** | **236.25 - 258.75** | 1.43% | 0.09% | 0.97% | 0.82% | 0.04% | 0.00% | 3.36% |
| **13** | **258.75 - 281.25** | 5.93% | 3.16% | 12.24% | 2.99% | 0.00% | 0.00% | 24.32% |
| **14** | **281.25 - 303.75** | 3.96% | 12.11% | 14.99% | 1.26% | 0.00% | 0.00% | 32.31% |
| **15** | **303.75 - 326.25** | 5.52% | 2.43% | 0.26% | 0.00% | 0.00% | 0.00% | 8.21% |
| **16** | **326.25 - 348.75** | 1.36% | 0.07% | 0.00% | 0.00% | 0.00% | 0.00% | 1.43% |
| | **Sub-Total** | 24.36% | 18.30% | 28.76% | 5.13% | 0.04% | 0.00% | 76.59% |
| | **Calms** | | | | | | | 23.41% |
| | **Missing/Incomplete** | | | | | | | 0.00% |
| | **Total** | | | | | | | 100.00% |

**Figure J-2**

**Station 2 Windrose**

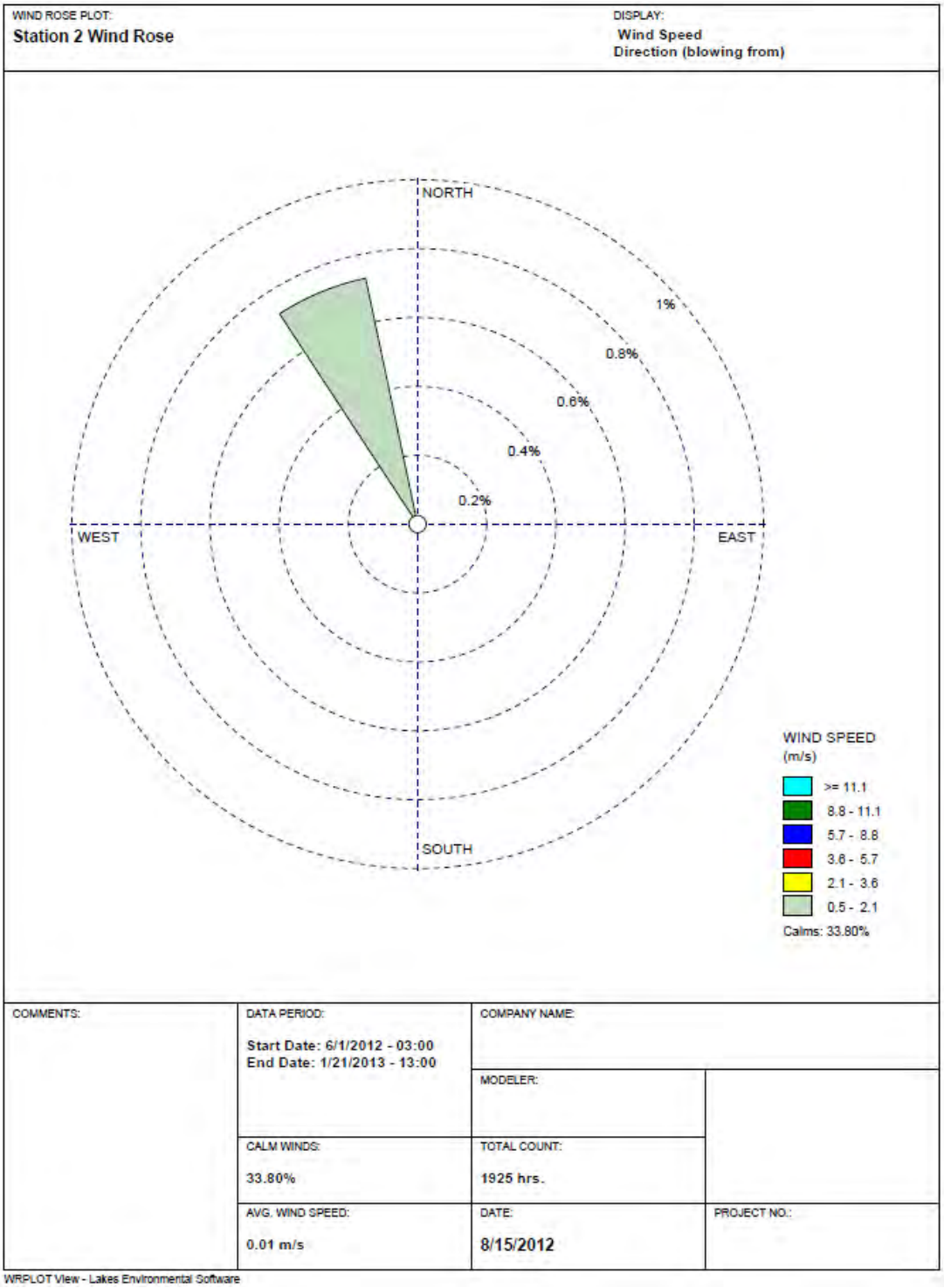


**Table J-2 Station 2 Wind Speed and Direction Frequency Distribution Table**

| | | Wind Speed Classes (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Wind Direction** | **0.0 - 2.1** | **2.1 - 3.6** | **3.6 - 5.7** | **5.7 - 8.8** | **8.8 - 11.1** | **>= 11.1** | **Total** |
| **1** | **348.75 - 11.25** | 0.05% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.05% |
| **2** | **11.25 - 33.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **3** | **33.75 - 56.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **4** | **56.25 - 78.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **5** | **78.75 - 101.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **6** | **101.25 - 123.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **7** | **123.75 - 146.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **8** | **146.25 - 168.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **9** | **168.75 - 191.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **10** | **191.25 - 213.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **11** | **213.75 - 236.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **12** | **236.25 - 258.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **13** | **258.75 - 281.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **14** | **281.25 - 303.75** | 0.07% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.07% |
| **15** | **303.75 - 326.25** | 0.16% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.16% |
| **16** | **326.25 - 348.75** | 3.15% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 3.15% |
| | **Sub-Total** | 3.43% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 3.43% |
| | **Calms** | | | | | | | 96.57% |
| | **Missing/Incomplete** | | | | | | | 0.00% |
| | **Total** | | | | | | | 100.00% |

**Figure J-3**

**Station 3 Windrose**

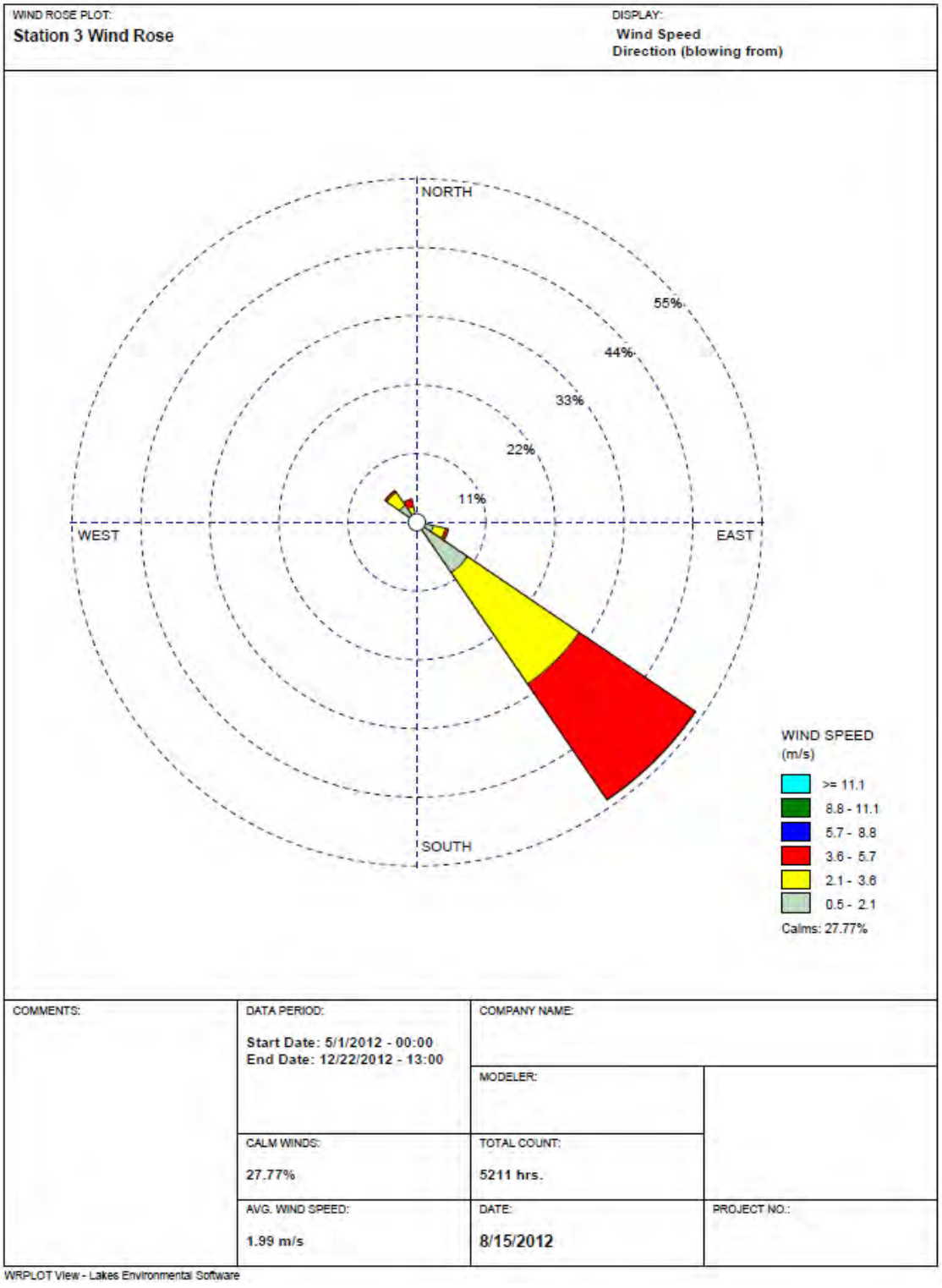


**Table J-3 Station 3 Wind Speed and Direction Frequency Distribution Table**

| | | Wind Speed Classes (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Wind Direction** | **0.0 - 2.1** | **2.1 - 3.6** | **3.6 - 5.7** | **5.7 - 8.8** | **8.8 - 11.1** | **>= 11.1** | **Total** |
| **1** | **348.75 - 11.25** | 0.32% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.32% |
| **2** | **11.25 - 33.75** | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% |
| **3** | **33.75 - 56.25** | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% |
| **4** | **56.25 - 78.75** | 0.05% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.05% |
| **5** | **78.75 - 101.25** | 0.27% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.27% |
| **6** | **101.25 - 123.75** | 3.91% | 1.77% | 0.50% | 0.00% | 0.00% | 0.00% | 6.17% |
| **7** | **123.75 - 146.25** | 12.63% | 19.84% | 20.64% | 0.05% | 0.00% | 0.00% | 53.17% |
| **8** | **146.25 - 168.75** | 1.20% | 0.05% | 0.00% | 0.00% | 0.00% | 0.00% | 1.26% |
| **9** | **168.75 - 191.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **10** | **191.25 - 213.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **11** | **213.75 - 236.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **12** | **236.25 - 258.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **13** | **258.75 - 281.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **14** | **281.25 - 303.75** | 0.05% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.05% |
| **15** | **303.75 - 326.25** | 4.90% | 2.32% | 0.35% | 0.00% | 0.00% | 0.00% | 7.57% |
| **16** | **326.25 - 348.75** | 1.17% | 1.57% | 1.17% | 0.00% | 0.00% | 0.00% | 3.91% |
| | **Sub-Total** | 24.53% | 25.56% | 22.66% | 0.05% | 0.00% | 0.00% | 72.80% |
| | **Calms** | | | | | | | 27.20% |
| | **Missing/Incomplete** | | | | | | | 0.00% |
| | **Total** | | | | | | | 100.00% |

## Figure J-4

## Station 4 Windrose

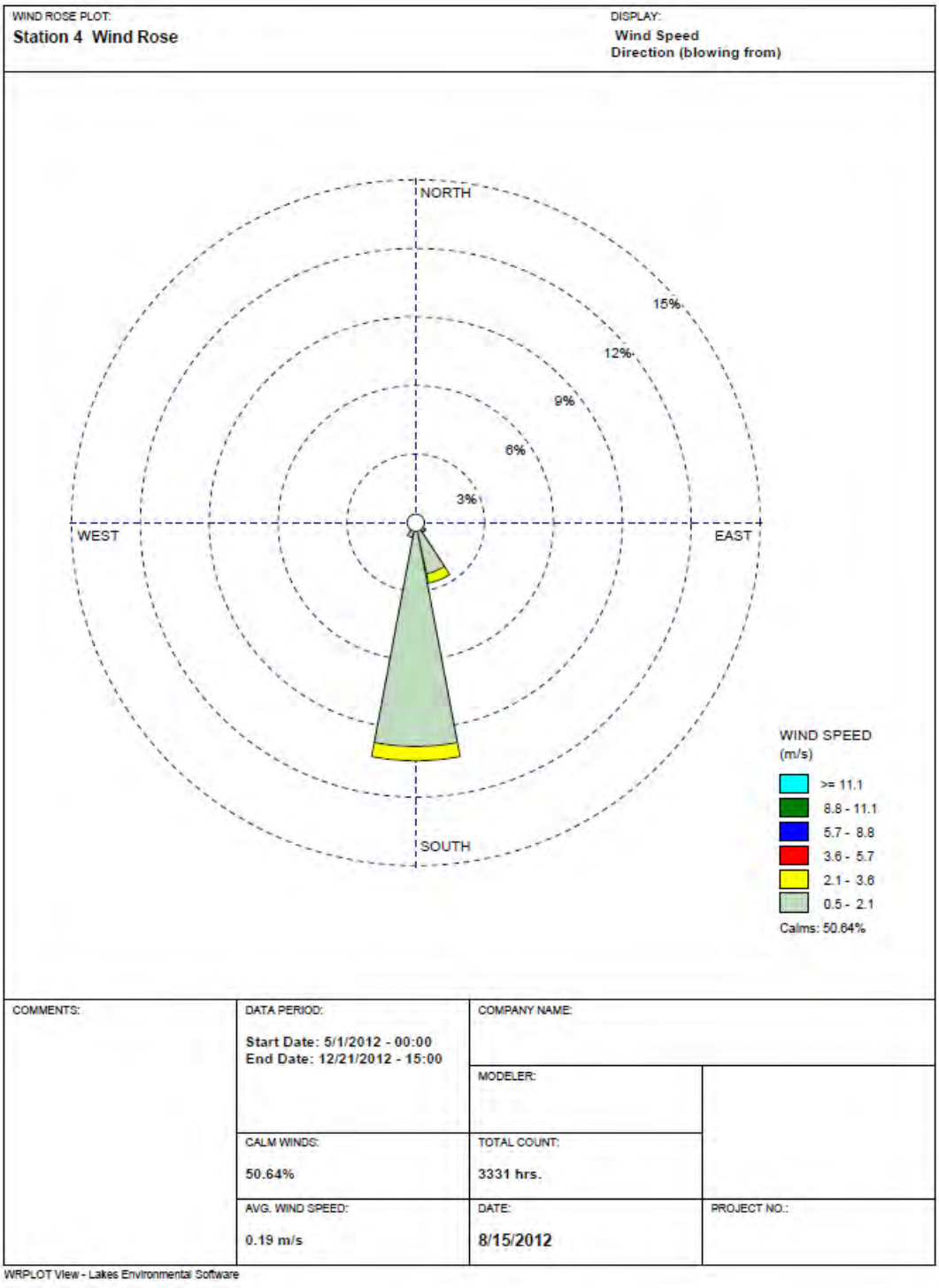


**Table J-4 Station 4 Wind Speed and Direction Frequency Distribution Table**

| | | Wind Speed Classes (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Wind Direction** | **0.0 - 2.1** | **2.1 - 3.6** | **3.6 - 5.7** | **5.7 - 8.8** | **8.8 - 11.1** | **>= 11.1** | **Total** |
| **1** | **348.75 - 11.25** | 0.37% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.37% |
| **2** | **11.25 - 33.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **3** | **33.75 - 56.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **4** | **56.25 - 78.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **5** | **78.75 - 101.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **6** | **101.25 - 123.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **7** | **123.75 - 146.25** | 0.55% | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.57% |
| **8** | **146.25 - 168.75** | 1.69% | 0.25% | 0.00% | 0.00% | 0.00% | 0.00% | 1.94% |
| **9** | **168.75 - 191.25** | 9.20% | 0.37% | 0.00% | 0.00% | 0.00% | 0.00% | 9.57% |
| **10** | **191.25 - 213.75** | 1.19% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 1.19% |
| **11** | **213.75 - 236.25** | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% |
| **12** | **236.25 - 258.75** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **13** | **258.75 - 281.25** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **14** | **281.25 - 303.75** | 0.75% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.75% |
| **15** | **303.75 - 326.25** | 0.50% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.50% |
| **16** | **326.25 - 348.75** | 0.11% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.11% |
| | **Sub-Total** | 14.36% | 0.64% | 0.00% | 0.00% | 0.00% | 0.00% | 15.00% |
| | **Calms** | | | | | | | 85.00% |
| | **Missing/Incomplete** | | | | | | | 0.00% |
| | **Total** | | | | | | | 100.00% |