Appendix A – Potential Recycled Water Customers

Figure ES-2: Recommended Project Target Recycled Water Users

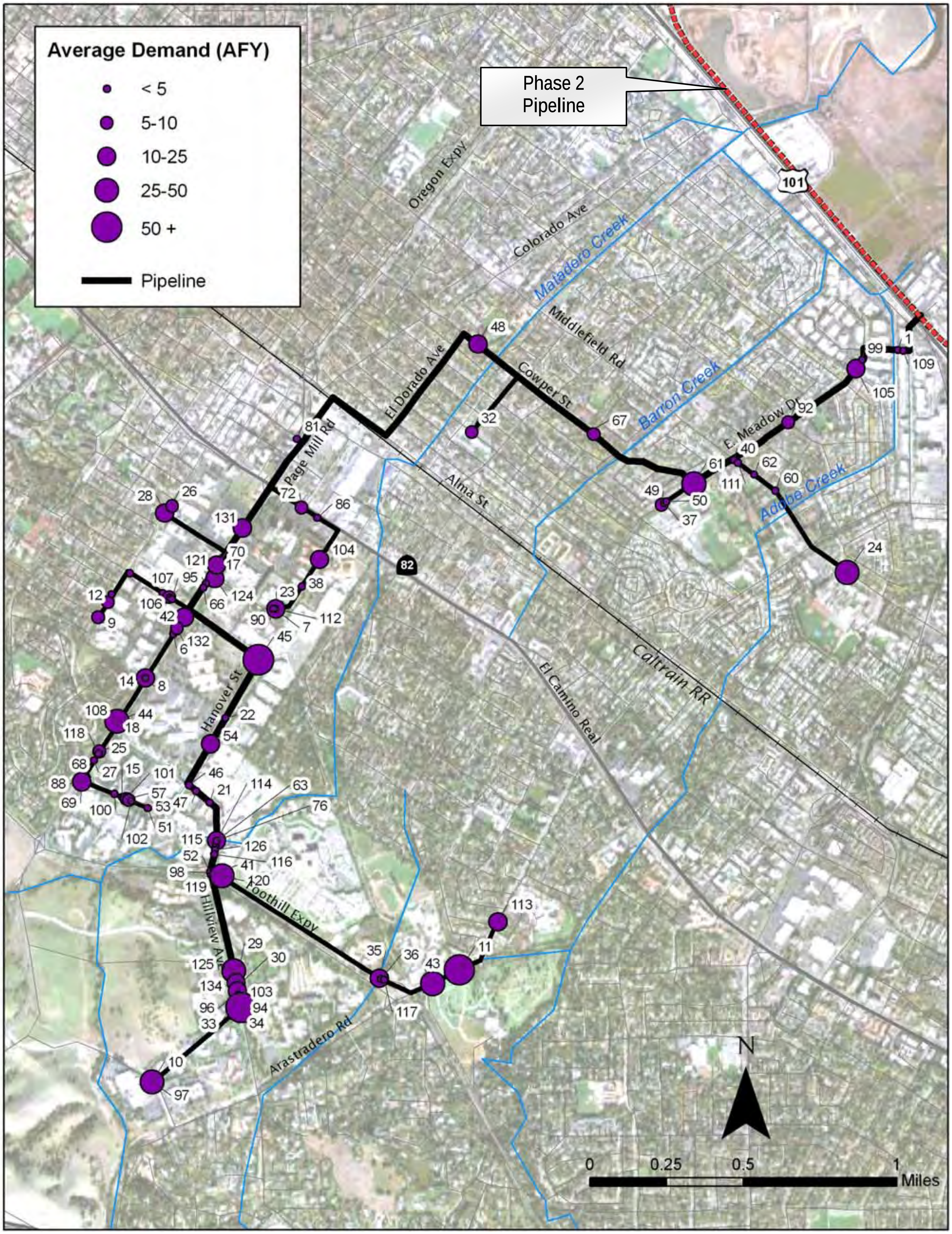

Table ES-1: Recommended Project Target Recycled Water Users

ID	Potential Customer	AFY[1]	ID	Potential Customer	AFY[1]
1	1101 E Meadow Housing	0.6	62	Mitchell Park Library	0.7
2	1451-1601 California Housing	0.0	63	Mozart Development	2.8
6	495 Java Drive Assoc	5.0	66	NYSE	1.9
7	850 Assoc C/O WSJ Prop	1.2	67	Our Lady of the Rosary School	6.2
8	940 E Meadow Housing	0.3	68	Page Mill Center	6.6
9	Agilent Technologies	8.6	69	Page Mill Rd Prop, Inc	11.3
10	Agilent Technologies	40.5	70	Paine Webber, Inc	2.1
11	Alta Mesa Memorial Park	92.9	72	Palo Alto Square	9.1
12	Alza	6.6	76	Pennie & Edmonds LLP	0.2
14	Beckman Instruments	12.2	81	Pkwy Cal/Birch	1.6
15	C & J Management	3.3	86	Pkwy El Camino	0.4
17	Carramerica Reality Corp	6.4	88	Pkwy Ore/Pg Mill	4.3
18	Carten - Trust	0.7	90	Prognostics	1.5
20	Clark Park	20.0	92	Ramos Park	7.6
21	CNF Transportation Inc	1.6	94	Roche Bioscience	76.7
22	Cooley Godward LLP	0.8	95	RWI Group	0.3
23	CPI	18.5	96	SAP Labs, Inc	11.2
24	Cubberley Community Center	29.4	97	SAP Labs, Inc	7.4
25	CV Therapeutics, Inc.	5.1	98	Simpson Thacher & Bartlet	2.3
26	DNAX Research Institute	8.3	99	Space Systems Loral	0.0
27	Dow Jones & Co	0.1	100	Stanford & Hines Interest	3.6
28	Dow Jones & Co	12.7	101	Stanford & Hines Interest	2.4
29	DPIX	21.0	102	Stanford & Hines Interest	1.8
30	ECI Deer Creek LLC	2.3	103	Stanford & Hines Interest	3.1
32	El Carmelo Elementary School	6.2	104	Stanford & Hines Interest	13.6
33	EPRI	4.0	105	Stanford & Hines Interest	12.8
34	EPRI	12.7	106	Stanford Hospital and Clinics	9.6
35	Equity Office Properties	13.3	107	Stanford Hospital and Clinics	2.8
36	Equity Office Properties	0.2	108	Stanford Univ	0.4
37	Fairmeadow Elementary School	1.6	109	Substation	0.1
38	Finnegan, Henderson LLP	1.5	111	Substation	0.0
40	Fire Station	0.3	112	Substation	0.0
41	Foothills Club	2.6	113	Terman Park	19.9
42	Genencor International, Inc	19.2	114	Tibco Software Inc	10.4
43	Gunn Senior High School	26.1	115	Tibco Software Inc	0.7
44	Hewlett Packard	29.2	116	Tibco Software Inc	0.4
45	Hewlett Packard	58.8	117	Tibco Software Inc	2.0
46	Hewlett Packard	1.9	118	Trinet Essential	4.6
47	Hewlett Packard	1.6	119	University Club of PA	3.0
48	Hoover Park	12.6	120	VA Palo Alto Health Care	37.7
49	Jane L Stanford Middle School	7.3	122	Varian Medical Systems	2.6
50	Jane L Stanford Middle School	4.1	124	Varian, Inc.	13.8
51	Legato Systems	2.0	125	VM Ware (prev. Stanford & Hines)	29.2
52	Liveops.com Inc	2.3	126	VMWare Inc	1.0
53	Lockheed Missiles & Space	6.3	131	Wilson/S/G/R	10.9
54	Lockheed Missiles & Space	15.3	132	Wilson/S/G/R	6.1
57	Matadero Creek	5.6	133	Wilson/S/G/R	0.6
60	Mitchell Park	1.9	134	Xerox Corp	7.2
61	Mitchell Park	25.7		**Total**	**916**

Note: Estimates are for average annual demand and include the Factor of Usage modifier described in Chapter 3.

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Appendix B –Notice of Preparation and NOP Scoping Meeting Sign-In Sheet

City of Palo Alto

Department of Planning and Community Environment
California Environmental Quality Act

NOTICE OF PREPARATION

TO: Responsible and Trustee Agencies, Organizations, and Interested Parties

FROM: City of Palo Alto
250 Hamilton Ave
Palo Alto, CA 94301

SUBJECT: Notice of Preparation of a Draft Environmental Impact Report (EIR) for the City of Palo Alto Utilities Recycled Water Project

The City of Palo Alto will be the lead agency under the California Environmental Quality Act (CEQA) and will prepare a project EIR for the project identified below.

AGENCIES: The City of Palo Alto requests the views of public agencies as to the scope and content of the environmental information that is germane to the agency's statutory responsibilities in connection with the proposed Project, in accordance with California Code of Regulations, Title 14, Section 15082(b), if the agency will need to use the EIR prepared by the City of Palo Alto when considering any permit or other approval for the project.

ORGANIZATIONS AND INTERESTED PARTIES: The City of Palo Alto requests comments and concerns from organizations and interested parties regarding the environmental issues associated with construction and operation of the proposed project.

PROJECT TITLE: City of Palo Alto Recycled Water Project

PROJECT LOCATION: The project is located in Central Palo Alto and Stanford Research Park

PROJECT DESCRIPTION: The Project consists of the installation of a recycled water pipeline, a booster pump station, and a pump station at the Palo Alto Regional Water Quality Control Plant (RWQCP) for the City of Palo Alto (in Santa Clara County) and represents the next increment of the RWQCP's ongoing expansion of its regional recycled water system.

The proposed Project would involve the construction of approximately 5 miles of 12 to 18-inch recycled water pipelines, a booster pump station, approximately 5 miles of lateral pipelines to over 50 use sites, and a pump station at the RWQCP. The Project would initially serve approximately 900 acre-feet[1] per year (AFY) of recycled water, primarily to the Stanford Research Park area. Other areas within Palo Alto that could be served by this project and are included in the environmental analysis are commercial uses and public spaces scattered along the proposed backbone and lateral pipeline routes. Future extensions could serve Stanford University and Los Altos Hills, as well as provide a loop by making a second connection to the Phase 2 Mountain View Project. When these future extensions are proposed, they would undergo project specific environmental review at that time, by the appropriate lead agency. The predominant use of recycled water for this Project is landscape irrigation. Some industrial use, such as commercial and light industrial cooling towers, could also be included at a later date.

Additional details on the Project are provided in Attachment A.

POTENTIAL ENVIRONMENTAL EFFECTS: The following areas of potentially significant environmental impact will be analyzed in the Draft EIR: Aesthetics, Air Quality, Biological Resources, Cultural Resources, Geology/Soils & Seismicity, Hazards & Hazardous Materials, Hydrology & Water Quality, Land Use & Planning, Noise, Population & Housing, Public Services, Recreation, Transportation & Traffic, Utilities & Service Systems, and

[1] An acre-foot equals 325,851 gallons

Climate Change. Potential cumulative impacts and potential for growth inducement will be addressed; alternatives, including the No Project Alternative, will be evaluated.

PUBLIC REVIEW PERIOD: This NOP is available for public review and comment pursuant to California Code of Regulations, Title 14, Section 15082(b) for 30 days. The comment period for the NOP begins June 16, 2011 and ends on July 18, 2011. Due to the limits mandated by State Law, your response must be sent at the earliest possible date but not later than 30 days after receipt of this notice.

RESPONSES AND COMMENTS: Please indicate a contact person for your agency and send your responses and comments to:

Clare Campbell, Planner
City of Palo Alto
250 Hamilton Avenue
Palo Alto, CA 94301
(650) 617-3191
Clare.Campbell@cityofpaloalto.org

SCOPING MEETING: The City of Palo Alto will hold a scoping meeting on July 12, 2011 from 7:00 p.m. to 9:00 p.m. (open house format) at the Fireside Room at the Lucie Stern Center in City of Palo Alto, 1305 Middlefield Road. You are welcome to attend and present environmental information that you believe should be addressed in the EIR.

The NOP and related CEQA/NEPA document(s) for this project will be available for review on the web. You can view the NOP electronically at:

http://www.cityofpaloalto.org/depts/utl/utilities_engineering/news/details.asp?NewsID=1239&TargetID=245

If you require additional project information, please contact Clare Campbell at (650) 617-3191.

Signature

6/13/2011

Date

ATTACHMENT A

Draft EIR Schedule

The City of Palo Alto is seeking input on the scope and content of environmental information relevant to the proposed Project, including input on environmental issues and alternatives to be addressed in the EIR. The Draft EIR is scheduled for circulation in late fall/early winter 2011.

Project Objectives

The objectives of the Project are to allow the City to maximize recycled water as a supplemental water source and to help the RWQCP and its partners to further protect the San Francisco Bay by reducing the wastewater constituent mass loadings[2] to the Bay. In addition, the Project would provide the following benefits to the community:

- An alternative water supply for irrigation during droughts when potable water use is restricted;
- Beneficially reuse the wastewater generated by the City;
- Reduce future potable water supply infrastructure costs to the City; and uphold state guidelines and policies relative to recycled water, including the California Water Code, Section 13510 and Section 461.

Background

The City prepared and publically circulated an Initial Study/Mitigated Negative Declaration (IS/MND) for this Project in March 2009. The environmental document contained an initial study checklist that evaluated impacts to the environment associated with construction and operation of the project. Comments were received during the 30-day public comment period, and the City completed a Response to Comments document in May 2009. Due to public concerns regarding the irrigation of redwood trees with recycled water, the City did not take action on the IS/MND. Since that time, the City has decided to prepare an EIR that focuses on the key issues of the project, including the effects of project operation on redwood trees.

Existing Facilities

The RWQCP is located on the San Francisco Bay in the northeastern portion of the City of Palo Alto. It provides wastewater treatment and disposal services to the cities of Palo Alto, Mountain View and Los Altos, the Town of Los Alto Hills, the East Palo Alto Sanitation District, and Stanford University, known collectively as the RWQCP Partners. The RWQCP has a design average dry-weather flow capacity of 39 million gallons per day (mgd) and a current flow of about 23 mgd.

Most of the effluent from the RWQCP is treated to the disinfected secondary-23[3] recycled water level and discharged to San Francisco Bay through an effluent outfall. The RWQCP also has a 4 mgd recycled

[2] Mass loading refers in this case to the net influx of chemical constituents entering the Bay.
[3] See CCR Title 22 for a definition of secondary-23 recycled water.

water facility that filters and disinfects the effluent to meet the requirements for tertiary treated water[4]. The RWQCP also has ultra-violet (UV) disinfection facilities that may increase the recycled water production capacity to 6.3 mgd, with the potential to further increase capacity to 8.6 mgd in the future. Recycled water is currently used at the RWQCP, the Palo Alto Municipal Golf Course, Emily Renzel Marsh and Greer Park in Palo Alto, and is also trucked to construction sites throughout the region for dust control.

Project Description

The Palo Alto Recycled Water Project proposes the construction of a recycled water pipeline and associated facilities to provide an alternative water supply for non-potable uses. The proposed Project would involve the construction of approximately 5 miles of 12- to 18-inch pipes, an up to 1,500 square-foot booster pump station, approximately 5 miles of lateral pipelines to over 50 use sites, and an up to 1,600 square-foot pump station at the RWQCP. The Project would initially serve approximately 900 acre-feet[5] per year (AFY) of recycled water, primarily to the Stanford Research Park area. Other areas within Palo Alto that could be served by this project and are included in the environmental analysis are commercial uses and public spaces scattered along the proposed backbone and lateral pipeline routes. Future extensions could serve Stanford University and Los Altos Hills, as well as provide a loop by making a second connection to the Phase 2 Mountain View Project. When these future extensions are proposed, they would undergo project specific environmental review at that time, by the appropriate lead agency. The predominant use of recycled water for this Project is landscape irrigation. Some industrial use, such as commercial and light industrial cooling towers, could also be included at a later date. The locations of the Project components are shown in Figure 1.

Pipelines

The proposed pipeline consists of the backbone pipeline and offshoots, or lateral pipelines. The pipeline would be located in urban areas, along existing road rights-of-ways (see Figure 1). The proposed backbone pipeline alignment would begin with a connection point to the Mountain View Project near the intersection of East Bayshore Road and Corporation Way. The pipeline would cross under US-101, and run along Fabian Way to East Meadow Drive where it would cross Adobe Creek. The pipeline would run along East Meadow Drive across Middlefield Road, and then continue along East Meadow Drive, Cowper Street, and El Dorado Avenue to Alma Street, along Alma Street to Page Mill Road, and along Page Mill Road to El Camino Real. The pipeline would continue across El Camino Real, along Page Mill Road to Hanover Street, and along Hanover Street and Hillview Avenue to Arastradero Road. Three pipeline alignment options (as shown in Figure 1) would potentially replace segments of the proposed backbone pipeline alignment depending on constructability and design considerations. Roads included in the backbone pipeline alignment, including the options, are detailed in Table 1.

Lateral pipeline alignments would run along existing side streets from the proposed alignment or alignment options to serve individual users as shown in Figure 1.

---

[4] Specifically the RWQCP treats effluent to meet the requirements for disinfected tertiary recycled water "unrestricted use" as defined in California Code of Regulations (CCR), Title 22, Sections 60301 through 60355.
[5] An acre-foot equals 325,851 gallons

Table 1: Proposed Backbone Pipeline Alignment

Alignment Location	Starting Cross Street	Ending Cross Street	Proposed Construction Method at Crossings
Proposed Alignment			
Under US-101	E. Bayshore Rd. at Corporation Way	Fabian Way	Trenchless under 101
Fabian Way	West Bayshore Road	East Meadow Drive	Open-Cut[1]
East Meadow Drive	Fabian Way	Cowper Street	Open-Cut; Potential trenchless[2] section across Adobe Creek Bridge
Cowper Street	East Meadow Drive	El Dorado Avenue	Open-Cut; Potential trenchless sections across Barron Creek Bridge and Matadero Creek Bridge
El Dorado Avenue	Cowper Street	Alma Street	Open-Cut
Alma Street	El Dorado Avenue	Page Mill Road	Open-Cut
Page Mill Road	Alma Street	Hanover Street	Open-Cut; Potential trenchless section under railroad crossing; Potential trenchless section under El Camino Real
Hanover Street	Page Mill Road	Hillview Avenue	Open-Cut
Hillview Avenue	Hanover Street	Arastradero Road	Open-Cut; Potential trenchless section across SFPUC Easement and Foothill Expressway
Pipeline Alignment Option 1			
Adobe Creek	US-101	West Bayshore Road	Trenchless under 101
West Bayshore Road	Adobe Creek	Fabian Way	Open-Cut
Pipeline Alignment Option 2			
Colorado Avenue	US-101	Alma Street	Open-Cut
Pipeline Alignment Option 3			
El Camino Real	Page Mill Road	Hanson Way	Open-Cut
Palo Alto Square Parking	Hanson Way	Hanover Street	Open-Cut

[1] The open-cut construction method involves long, narrow excavations in the ground to accommodate the placement of the pipelines.

[2] All of the bridge crossings would be trenchless (constructed with the pipe attached to the side of the bridge or installed underneath the creek). The construction method has not been finalized. Neither method would require work to be done in the creeks.

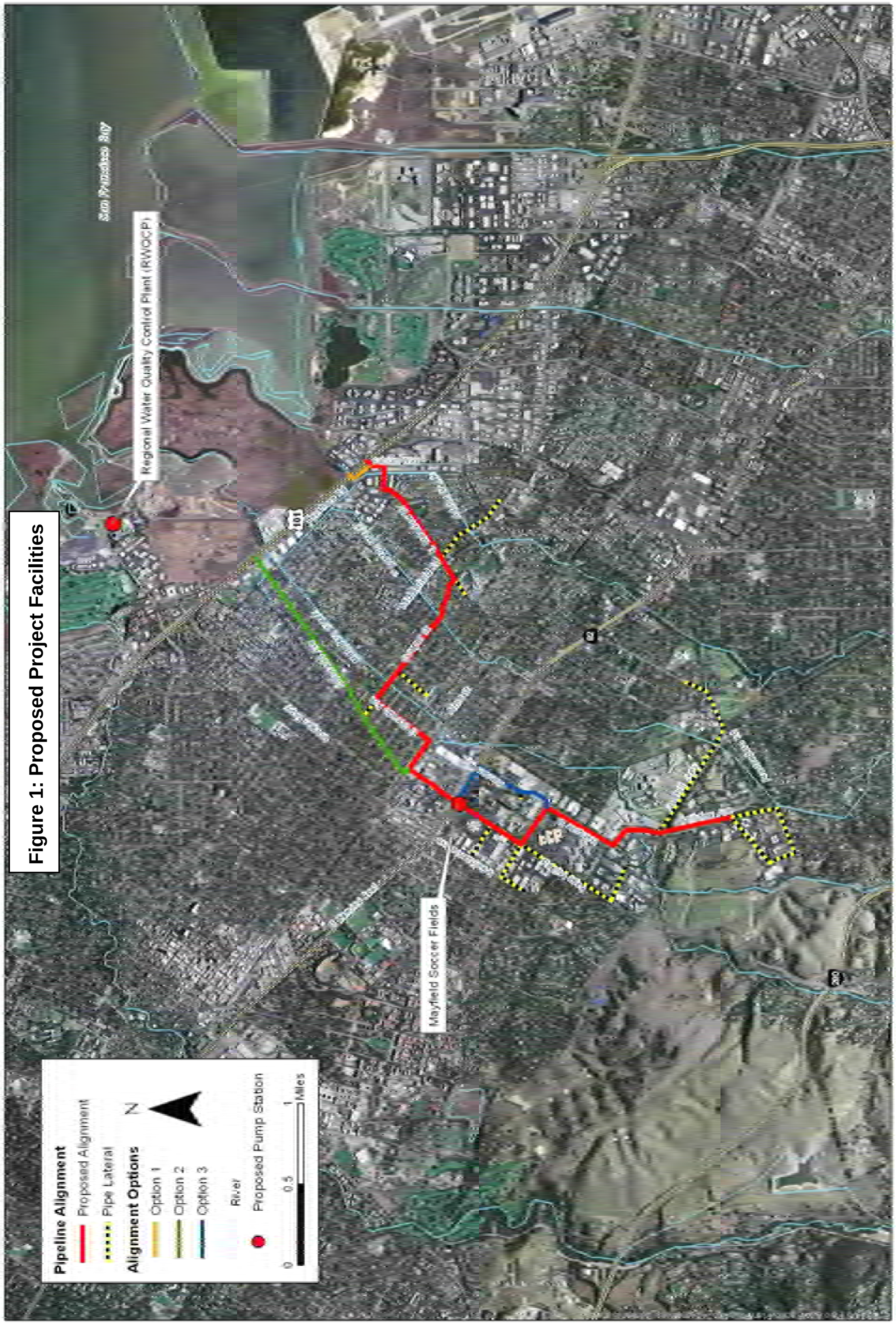

Figure 1: Proposed Project Facilities

Booster Pump Station

A booster pump station would be constructed as part of the proposed Project to maintain a minimum delivery pressure for end users. The proposed booster pump station would be located at 2700 El Camino Real, on the southeast corner of Page Mill Road and El Camino Real intersection at the Mayfield Soccer Fields (see Figure 1). The site is on the proposed alignment and located in a strategic area for delivering recycled water to the majority of demands along the pipeline. The park is owned by Stanford and leased to the City of Palo Alto.

The proposed booster pump station would be constructed below grade at the site due to the prominent visual location and to avoid impacts to the existing park uses. The pump station would have a peak flow rate of 2,860 gallons per minute (GPM) which would require a total installed horsepower (hp) of 400 hp, including standby pumps. The footprint would be approximately 50-ft x 30-ft (1,500 square feet).

In addition to the booster pump station, a back-up generator may be installed at a later date if the recycled water is supplied for industrial use in the future. The back-up generator would be a stationary unit that only operates on a temporary basis under emergency conditions (e.g., power outage). In the event that a back-up generator is installed, diesel fuel would be stored on site within double-walled concrete containers. Likely, both the generator and storage would be bounded by a fence or structure (for security) and architectural treatment would be applied to integrate its façade with surrounding uses. The overall dimensions of the fenced area/structure could be up to 11 x 7 x 8 feet (length x width x height). The proposed generator facility would be designed to minimize noise. The above grade structures and improvements would be subject to the City's design review to address all aesthetic concerns.

RWQCP Pump Station

Additional pumping capacity would be necessary at the RWQCP to achieve the minimum pressure at the Phase 2 connection point during peak flows to accommodate the Project. The RWQCP pump station would have a capacity of 4.8 mgd (3,310 gpm) requiring a 350 hp facility at the location identified in Figure 1. The pump station could require a footprint of up to 40-ft x 42-ft (1,680 square feet) and would be up to 12 feet tall. The pump station would be enclosed or covered. This structure would be subject to the City's design review to address all aesthetic concerns.

Project Construction

Construction of the backbone and lateral pipelines would generally consist of open-cut construction, except at the crossings. In addition, another form of trenchless construction, horizontal directional drilling (HDD), may be used along the entire alignment. The open-cut trench width would be approximately three feet and depth would be approximately five feet. The use of HDD would require entry and exit pits at regular intervals and pipeline alignment turns for drilling operations and pipeline installation.

Pipeline construction would typically require a minimum of one lane of traffic and the adjacent shoulder and/or bike lane (if they exist), resulting in a construction corridor approximately 20 feet to 30 feet wide. It is expected that open trench construction within paved roadways would proceed at the rate of approximately 100 feet per day, with an overall work zone of 300 to 600 feet in length. Excavated trench materials would be sidecast within approved work areas and reused as appropriate for backfill. After pipeline construction and installation is complete, pavement would be restored to preconstruction conditions.

Construction would occur for a relatively brief period of time at any one location along the pipeline alignment, at most a few days. Construction would occur between the hours of 9 am and 4 pm Monday through Friday on arterial and collection streets in order to maintain compliance with the City's Traffic Control Requirements. Construction other than on arterial and collection streets would occur between the hours of 8 am and 6 pm Monday through Friday. Construction would occur between 9 am and 6 pm on Saturday for all construction areas. The alignment of the pipeline is shown in Figure 1 and described in Table 1.

Trenchless construction methods would be used for selected roadway and creek crossings. Trenchless construction methods minimize the area of surface disruption required for pipeline installation and include: jack and bore, micro-tunneling, directional drilling, and tunneling techniques. Hanging pipelines on existing bridge structures is another potential trenchless approach. Crossings where trenchless construction techniques would be implemented are described in Table 2.

Table 2: Trenchless Creek and Road Crossings

Location	Crossing
Adobe Creek	US 101
	East Meadow Drive
	Middlefield Road*
Barron Creek	Cowper Street
	Miranda Avenue*
Matadero Creek	Cowper Street
	Hillview Avenue
Page Mill Road	Railroad crossing between Alma Street and Park Boulevard
	El Camino Real
Hillview Avenue	San Francisco Public Utilities Commission (SFPUC) easement at intersection of Foothill Expressway
	Foothill Expressway

*Lateral pipeline

All pipeline construction would occur within public roadways. An easement from California Department of Transportation (Caltrans) would be required to construct the pipeline across and along US-101. An easement from Santa Clara Valley Water District (SCVWD) would be required to cross all creeks.

The booster pump station would be constructed on leased property at the Mayfield Soccer Fields (Figure 1). The construction footprint for the pump station at the Mayfield Soccer Fields would be approximately 0.25 acres. The pump station proposed at the RWQCP would be constructed entirely within existing City property.

Staging areas would be set up along the pipeline alignments, and at selected locations, such as adjacent to the proposed pump station at the Mayfield Soccer Fields and the RWQCP.

Palo Alto Recycled Water Project
7/12/11

Name	Affiliation	Contact Info
Meredith Durant	Resident & Consultant	(415) 243-2534
Greg Conlon	Sharon Hts G & CC	650-315-4956

Appendix C – Distribution List and Public Comments Received on the NOP

NOP Distribution List

Addresses

OFFICE OF PLANNING & RESEARCH
STATE CLEARINGHOUSE
1400 TENTH STREET, ROOM 222
SACRAMENTO, CA 95814

USFWS
Endangered Species Division
2800 Cottage Way, suite W2605
Sacramento, Ca 95825-3901

US CORPS OF ENGINEERS
1455 MARKET STREET FL 17
SAN FRANCISCO, CA 94103-1368

BAY AREA AIR QUALITY MANAGEMENT DISTRICT
ATTENTION: SUZANNE BOURGUIGNON
939 ELLIS STREET
SAN FRANCISCO, CA 94109

Purissima Hills Water District
26375 Fremont Rd
Los Altos Hills, CA 94022

Palo Alto Hills Golf and Country Club
3000 Alexis Drive
Palo Alto, CA 94304

Sharon Heights Golf and Country Club
ATTN: Greg Conlin
2900 Sand Hill Rd
Menlo Park, CA 94025

Clerk-Recorder's Office
East Wing, First floor
70 West Hedding Street
(at First Street)
San Jose CA 95110

San Francisco Bay Conservation and
Development Commission
50 California Street, Suite 2600
San Francisco, California 94111

City of Menlo Park
ATTN: Planning Division
701 Laurel St
Menlo Park, CA 94025

City of Los Altos
ATTN: Planning Division
One North San Antonio Rd
Los Altos, CA 94022

Los Altos Hills
ATTN: Planning Department
26379 Fremont Rd
Los Altos Hills, CA 94022

Palo Alto Airport
1925 Embarcadero Road
Palo Alto, CA 94303

State Water Resources Control Board
Division of Financial Assistance
ATTN: James Hockenberry
PO Box 944212
Sacramento, CA 94244-2120

County of Santa Clara
Planning Office
70 W. Hedding Street
East Wing, 7th Floor
San Jose, CA 95110

SANTA CLARA VALLEY TRANSPORTATION
AUTHORITY (VTA)
ATTN: Roy Molseed
3331 N. FIRST STREET
SAN JOSE, CA 95134-1906

Santa Clara Valley Water District
ATTN: Usha Chatwani
5750 Almaden Expwy
San Jose, CA 95118-3686

Santa Clara Valley Water District
ATTN: Sue Tippets
5750 Almaden Expwy
San Jose, CA 95118-3686

California Department of Transportation
ATTN: Lisa Carboni
PO Box 23660
Oakland, CA 94623-0660

Department of Toxic Substances Control
ATTN: Patrick Lee
700 Heinz Avenue
Berkeley, CA 94710-2721

State Water Resources Control Board
ATTN: Madeleine Hirn
1001 I Street, 16th Floor
Sacramento, CA 95814

State Water Resources Control Board
ATTN: Michelle Lobo
1001 I Street, 16th Floor
Sacramento, CA 95814

United States Bureau of Reclamation
ATTN: Doug Kleinsmith
2800 Cottage Way, MP-150
Sacramento, CA 95825-1898

Stanford Real Estate Office
ATTN: Jim Inglis
2755 Sand Hill Road, Suite 100
Menlo Park, CA 94025

Canopy
ATTN: Catherine Martineau
3951 East Bayshore Road
Palo Alto, CA 94303

Palo Alto Baylands Nature Preserve
1305 Middlefield Road
Palo Alto, CA 94301

Staff

Catherine Martineau
Executive Director

Michael Hawkins
Program Director

Elliott Wright
Development Director

Board of Directors

Susan Ellis
Chair

Marty Deggeller
Vice-Chair

Roy C. Leggitt, III
Secretary

Beth Lim
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Urban K. Cummings

Carole Langston

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Carroll Harrington
Joe Hirsch
Leannah Hunt
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Jeanne Kennedy
John McClenahan
Mary McCullough
Scott McGilvray
Brooks Nelson
Nancy Peterson
Forest Preston, III
Susan Rosenberg
Jane Stocklin
Lauren Bonar Swezey
Lanie Wheeler

CANOPY is a Palo Alto based nonprofit advocate for the urban forest and works to educate, inspire and engage the community as stewards of young and mature trees.

June 21, 1011

Ms. Clare Campbell, Planner
City of Palo Alto
250 Hamilton Avenue
Palo Alto, CA 94301

Dear Ms. Campbell,

Thank you for giving us an opportunity to comment on the Notice of Preparation (NOP) of a Draft Environmental Impact Report (EIR) for the City of Palo Alto Utilities Recycled Water Project, dated 6/13/2011.

The mission of Canopy is to engage the community in growing and caring for our urban forest. Trees bring many tangible benefits to Palo Alto. In line with our mission, the following are Canopy's comments.

The NOP fails to address the effect that the proposed distribution of recycled water might have on the Palo Alto urban forest.

A recent report conducted for the City by the Davey Resource Group, based solely on the street tree inventory performed a few months ago, states:

> "The analysis determined that Palo Alto's right-of-way tree population is a cost-effective resource that provides annual benefits of $6,638,513 ($103.73 per capita). These benefits include energy savings, air quality improvements, stormwater interception, atmospheric CO_2 reduction, and aesthetic contributions to the social and economic health of the community. Considering the annual investment of $2,064,000 ($32.25 per capita) to provide care for this resource, the community realizes an overall net benefit of $4,574,513. The bottom line is that for every $1 spent on public trees, the community of Palo Alto receives $3.22 in benefits. "

In addition a survey conducted by the City in the context of the Urban forest Master Plan effort gathered the opinion of 800 residents who overwhelmingly expressed their deep attachment and appreciation for trees in Palo Alto.

Canopy requests that the draft EIR present a comprehensive assessment of the potential risk associated with the use of recycled water for landscape irrigation on the trees present in the various pipeline distribution target areas.

In particular we have questions or concerns about the following areas of the NOP:

- Species other than Redwoods
  While Redwoods are particularly sensitive to high salinity levels in irrigation water, they are not the only sensitive species. Public concerns associated to the IS/MND were *not* limited to the irrigation of Redwood trees with recycled water.

- Salinity issues specific to the Palo Alto RWQCP
  The main problem associated with using recycled water for landscape irrigation is that this water typically contains high level of salts. Plants, unlike humans, cannot eliminate these salts and the accumulation of salts in the root area can be very detrimental to trees. Additionally salinity levels in the recycled water produced by the RWQCP are particularly high. While a plan is in place to reduce salinity levels, it is uncertain when this reduction will be achieved.

We would like the EIR to answer questions such as the following in order to quantify the project's risks:

- How many trees are present in the target areas and what is the distribution of species according to their tolerance of various salinity levels?
- What is the nature of soils in the target areas?
- What is the estimated value of the investment made in these trees, their replacement value and the annual value of the ecosystem services provided by these trees?
- What is the indirect impact of the potential tree loss risk on the various areas of environmental impact that will be analyzed in the EIR as listed in the NOP?

This assessment would help the community consider trade-offs and make decisions regarding the appropriateness of using potable vs. recycled water to irrigate the trees that contribute greatly to the quality of life in Palo Alto and determine whether it is willing to take the risk of losing part of this asset and yearly payback it provides.

In addition we ask that the following be consulted in this process:

- independent experts
- both current and retired City Staff familiar with the effect of recycled water on trees
- stakeholders involved in the drafting of the Urban Forest Master Plan

Thank you for your attention to these comments.

Best regards,

C. Martineau

Catherine Martineau
Executive Director

State Water Resources Control Board

Division of Financial Assistance
1001 I Street • Sacramento, California 95814 • (916) 341-5700 FAX (916) 341-5707
Mailing Address: P.O. Box 944212 • Sacramento, California • 94244-2120
Internet Address: http://www.waterboards.ca.gov

Linda S. Adams
Acting Secretary for Environmental Protection

Edmund G. Brown Jr.
Governor

JUN 2 8 2011

Ms. Clare Campbell
City of Palo Alto
250 Hamilton Avenue
Palo Alto, CA 94301

Dear Ms. Campbell:

NOTICE OF PREPARATION (NOP) FOR THE CITY OF PALO ALTO (CITY); CITY OF PALO ALTO RECYCLED WATER PROJECT (PROJECT); SANTA CLARA COUNTY; STATE CLEARINGHOUSE NO. 2011062037

We understand the City is pursuing funds through the Clean Water State Revolving Fund (CWSRF) Program for the Project (CWSRF No. C-06-5171-110). As a funding agency and a state agency with jurisdiction by law to preserve, enhance, and restore the quality of California's water resources, the State Water Resources Control Board (State Water Board) is providing the following information on the NOP prepared for the Project.

Please provide us with the following documents applicable to the proposed Project: (1) two copies of the draft and final Environmental Impact Report (EIR), (2) the resolution certifying the EIR, adopting the Mitigation Monitoring and Reporting Program (MMRP), and Statements of Overriding Consideration, as applicable, and making California Environmental Quality Act (CEQA) findings, (3) all comments received during the review period and the City response to those comments, (4) the City's adopted MMRP, and (5) the Notice of Determination filed with the Governor's Office of Planning and Research. In addition, we would appreciate notice of any hearings or meetings held regarding environmental review of any projects to be funded by the State Water Board.

The CWSRF Program is partially funded by the U.S. Environmental Protection Agency (USEPA) and requires additional "CEQA-Plus" environmental documentation and review. Three information sheets are included that further explain the environmental review process and additional federal requirements in the CWSRF Program. In addition, an environmental evaluation form is included for the City to submit to the State Water Board Project Manager. The State Water Board can consult directly with agencies responsible for implementing federal environmental laws and regulations. Any environmental issues raised by federal agencies or their representatives will need to be resolved prior to State Water Board approval of a CWSRF financing commitment for the proposed Project. For further information on the CWSRF Program, please contact Ms. Michelle Lobo at (916) 341-6983.

It is important to note that prior to a CWSRF financing commitment, Projects are subject to provisions of the Federal Endangered Species Act and must obtain approval from the U.S. Fish and Wildlife Service (USFWS), and/or the National Marine Fisheries Service (NMFS) for any potential effects to special status species. Please be advised that the State Water Board can consult with USFWS, and/or NMFS on behalf of the City regarding all federal special status species the Project has the potential to impact. The City will need to identify whether the Project will involve any direct or indirect effects from construction activities that may affect federally-listed threatened, endangered, or candidate species that are known, or have a potential to occur on-site, in the surrounding areas, or in the service area.

In addition, CWSRF projects must comply with federal laws pertaining to cultural resources, specifically Section 106 of the National Historic Preservation Act. The State Water Board has been delegated responsibility for carrying out the requirements of Section 106 under a Nationwide Programmatic Agreement executed for the CWSRF Program by the USEPA, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers.

As stated above, the State Water Board has responsibility for ensuring compliance with Section 106, and the State Water Board Cultural Resources Officer (CRO) consults directly with the California State Historic Preservation Officer (SHPO). SHPO consultation is initiated when sufficient information is provided by the CWSRF applicant for projects having potential impacts to cultural resources. Please contact the State Water Board CRO Ms. Cookie Hirn at (916) 341-5690, to find out more about the requirements, and any questions on beginning the Section 106 compliance process. Note that the City will need to identify the Area of Potential Effects (APE), including construction, staging areas, and depth of any excavation.

Please provide the CRO with a copy of a current records search for the Project area, including maps that show all recorded sites and surveys in relation to the APE for the Project. Also include the cultural resources studies that were conducted for previous wastewater treatment plant expansion projects. The APE is three dimensional, and includes all areas that may be affected by the Project. The APE includes the surface area and extends below ground to the depth of any Project excavations. The records search request should be made for an area larger than the APE. The appropriate area varies for different projects, but should be drawn large enough to provide information on what types of sites may exist in the vicinity.

Native American and Interested Party Consultation is required for Section 106 compliance:

- A Project description and map should be sent to the Native American Heritage Commission (NAHC). The NAHC will provide a list of Native American tribes and individuals that are culturally affiliated with your Project area and recommend they all be contacted
- A Project description and map should be sent to everyone on the list provided by the NAHC, asking for information on the Project area
- Similar letters should be sent to local historical organizations
- Follow-up contact should be made by phone, if possible, and a phone log should be includedo

Comments from the NAHC, local tribes, and historical organizations affiliated with the Project area, as well as City response to these comments should be included in the submittal to the CRO. The NAHC can be contacted at:

915 Capitol Mall, Room 364
Sacramento, CA 95814
(916) 653-4082

Other federal requirements pertinent to the Project under the CWSRF Program include the following:

A. Compliance with the federal Clean Air Act (CAA): (a) Provide air quality studies that may have been done for the Project; and (b) if the Project is in an attainment or nonattainment area subject to a maintenance plan; (i) provide a summary of the estimated emissions (in tons per year) that are expected from both the construction and operation of the Project for each federal criteria pollutant in a nonattainment or maintenance area, and indicate if the nonattainment designation is moderate, serious, severe, or extreme (if applicable); (ii) if emissions are above the federal de minimis levels, but the Project is sized to meet only the needs of current population projections that are used in the approved State Implementation Plan for air quality, quantitatively indicate how the proposed capacity increase was calculated using population projections.

B. Compliance with the Migratory Bird Treaty Act (Act): List any birds protected under the Act that may be impacted by the Project and identify conservation measures to minimize impacts.

C. Protection of Wetlands: Identify whether or not the Project, or construction activities will impact streams, flood control, or wetlands, and measures to minimize such impacts.

D. Compliance with the Coastal Zone Management Act: Identify whether the Project is within a coastal zone, and the status of any coordination with the California Coastal Commission.

E. Flood Plain Management: Identify whether or not the Project is in a Flood Management Zone, and include a copy of the Federal Emergency Management Agency flood zone maps for the Project area.

F. Compliance with the Farmland Protection Policy Act: Identify whether the Project will result in the conversion of farmland. State the status of farmland (Prime, Unique, or Local and Statewide Importance) in the Project area and determine if this area is under a Williamson Act Contract.

G. Compliance with the Wild and Scenic Rivers Act: Identify whether or not any Wild and Scenic Rivers would be potentially impacted by the Project and include conservation measures to minimize such impacts.

The State Water Board has no further comments on the NOP at this time. Thank you for the opportunity to review the City's environmental document. We look forward to reviewing the EIR. If you have any questions or concerns, please feel free to contact me at (916)327-9401 or by email at LDLEE@waterboards.ca.gov, or contact Ms. Jessica Henderson-McBean at (916) 327-9117 or by email at JHenderson-McBean@waterboards.ca.gov.

Sincerely,

Lisa Lee
Environmental Scientist

Enclosures (4)

cc: State Clearinghouse (w/o enclosures)
(Re: SCH# 2011062037)
P.O. Box 3044
Sacramento, CA 95812-3044

BASIC CRITERIA FOR CULTURAL RESOURCES REPORTS

FOR SECTION 106 CONSULTATION WITH THE STATE HISTORIC PRESERVATION OFFICER (SHPO) UNDER THE NATIONAL HISTORIC PRESERVATION ACT (NHPA)

CURRENT RECORDS SEARCH INFORMATION

- A current (less than a year old) records search from the appropriate Information Center is necessary. The records search should include maps that show all recorded sites and surveys in relation to the area of potential effects (APE) for the project.
- The APE is three-dimensional and includes all areas that may be affected by the project. It includes the surface area and extends below ground to the depth of any project excavations.
- The records search request should be made for an area larger than the APE. The appropriate area varies for different projects but should be drawn large enough to provide information on what types of sites may exist in the vicinity.

NATIVE AMERICAN AND INTERESTED PARTY CONSULTATION

- Native American and interested party consultation should be initiated at the beginning of any cultural resource investigations. The purpose is to gather information from people with local knowledge that may be used to guide research.
- A project description and map should be sent to the Native American Heritage Commission (NAHC) requesting a check of their Sacred Lands Files. The Sacred Lands Files include religious and cultural places that are not recorded at the information centers.
- The NAHC will include a list of Native American groups and individuals with their response. A project description and maps should be sent to everyone on the list asking for information on the project area.
- Similar letters should be sent to local historical organizations.
- Follow-up contact should be made by phone if possible and a phone log should be included in the report.

REPORT TERMINOLOGY

- A cultural resources report used for Section 106 consultation should use terminology consistent with the NHPA.

- This doesn't mean that the report needs to "filled" with passages and interpretations of the regulations, the SHPO reviewer already knows the law.

- If "findings" are made they must be one of the four "findings" listed in Section 106. These include:

  "No historic properties affected" (no properties are within the APE, including the below ground APE).

  "No effect to historic properties" (properties may be near the APE but the project will not impact them).

  "No adverse effect to historic properties" (the project may affect historic properties but the impacts will not be adverse)

  "Adverse effect to historic properties". *Note: the SHPO must be consulted at this point. If your consultant proceeds on his own, his efforts may be wasted.*

WARNING PHRASES IN ALREADY PREPARED CEQA REPORTS

- A finding of **"no known resources"**, this doesn't mean anything. The consultant's job is to find out if there are resources within the APE or to explain why they are not present.

- **"The area is sensitive for buried archaeological resources",** followed by a statement that **"monitoring is recommended as mitigation".** Monitoring is not an acceptable mitigation. A reasonable effort should be made to find out if buried resources are present in the APE.

- **"The area is already disturbed by previous construction",** this may be true, but documentation is still needed to show that the new project will not affect cultural resources. As an example, an existing road can be protecting a buried archaeological site. Or, previous construction may have impacted an archaeological site that was never documented.

- No mention of **"Section 106"**, a report that gives adequate information for CEQA may not be sufficient to comply with Section 106.

Please contact me with any questions.

Cookie Hirn
SWRCB
Cultural Resources Officer
916-341-5690
Mhirn@waterboards.ca.gov

NATIVE AMERICAN HERITAGE COMMISSION
915 CAPITOL MALL, ROOM 364
SACRAMENTO, CA 95814
(916) 653-4082
(916) 657-5390 - Fax

July 15, 2011

RECEIVED

JUL 18 2011

Department of Planning &
Community Environment

Clare Campbell
City of Palo Alto
250 Hamilton Avenue, 6th Floor
Palo Alto, CA 94301

RE: SCH# 2011062037 Recycled Water Project; Santa Clara County.

Dear Ms. Campbell;

The Native American Heritage Commission (NAHC) has reviewed the Notice of Preparation (NOP) referenced above. The California Environmental Quality Act (CEQA) states that any project that causes a substantial adverse change in the significance of an historical resource, which includes archeological resources, is a significant effect requiring the preparation of an EIR (CEQA Guidelines 15064(b)). To comply with this provision the lead agency is required to assess whether the project will have an adverse impact on historical resources within the area of project effect (APE), and if so to mitigate that effect. To adequately assess and mitigate project-related impacts to archaeological resources, the NAHC recommends the following actions:

✓ Contact the appropriate regional archaeological Information Center for a record search. The record search will determine:
  - If a part or all of the area of project effect (APE) has been previously surveyed for cultural resources.
  - If any known cultural resources have already been recorded on or adjacent to the APE.
  - If the probability is low, moderate, or high that cultural resources are located in the APE.
  - If a survey is required to determine whether previously unrecorded cultural resources are present.

✓ If an archaeological inventory survey is required, the final stage is the preparation of a professional report detailing the findings and recommendations of the records search and field survey.
  - The final report containing site forms, site significance, and mitigation measurers should be submitted immediately to the planning department. All information regarding site locations, Native American human remains, and associated funerary objects should be in a separate confidential addendum, and not be made available for public disclosure.
  - The final written report should be submitted within 3 months after work has been completed to the appropriate regional archaeological Information Center.

✓ Contact the Native American Heritage Commission for:
  - A Sacred Lands File Check. . **USGS 7.5 minute quadrangle name, township, range and section required.**
  - A list of appropriate Native American contacts for consultation concerning the project site and to assist in the mitigation measures. **Native American Contacts List attached.**

✓ Lack of surface evidence of archeological resources does not preclude their subsurface existence.
  - Lead agencies should include in their mitigation plan provisions for the identification and evaluation of accidentally discovered archeological resources, per California Environmental Quality Act (CEQA) §15064.5(f). In areas of identified archaeological sensitivity, a certified archaeologist and a culturally affiliated Native American, with knowledge in cultural resources, should monitor all ground-disturbing activities.
  - Lead agencies should include in their mitigation plan provisions for the disposition of recovered artifacts, in consultation with culturally affiliated Native Americans.
  - Lead agencies should include provisions for discovery of Native American human remains in their mitigation plan. Health and Safety Code §7050.5, CEQA §15064.5(e), and Public Resources Code §5097.98 mandates the process to be followed in the event of an accidental discovery of any human remains in a location other than a dedicated cemetery.

Sincerely,

Katy Sanchez

Katy Sanchez
Program Analyst
(916) 653-4040

cc: State Clearinghouse

Native American Contact List
Santa Clara County
July 15, 2011

Indian Canyon Mutsun Band of Costanoan
Ann Marie Sayers, Chairperson
P.O. Box 28 — Ohlone/Costanoan
Hollister , CA 95024
ams@indiancanyon.org
831-637-4238

Amah/MutsunTribal Band
Irene Zwierlein, Chairperson
789 Canada Road — Ohlone/Costanoan
Woodside , CA 94062
amah_mutsun@yahoo.com
(650) 851-7747 - Home
(650) 851-7489 - Fax

Jakki Kehl
720 North 2nd Street — Ohlone/Costanoan
Patterson , CA 95363
jakki@bigvalley.net
(209) 892-1060

Amah MutsunTribal Band
Edward Ketchum
35867 Yosemite Ave — Ohlone/Costanoan
Davis , CA 95616 — Northern Valley Yokuts
aerieways@aol.com

Trina Marine Ruano Family
Ramona Garibay, Representative
30940 Watkins Street — Ohlone/Costanoan
Union City , CA 94587 — Bay Miwok
soaprootmo@msn.com — Plains Miwok
510-972-0645-home — Patwin
209-688-4753-cell

Amah/Mutsun Tribal Band
Joseph Mondragon, Tribal Administrator
882 Bay view Avenue — Ohlone/Costanoan
Pacific Grove, CA 94062
831-372-9015
831-372-7078 - fax

Amah MutsunTribal Band
Valentin Lopez, Chairperson
PO Box 5272 — Ohlone/Costanoan
Galt , CA 95632
vlopez@amahmutsun.org
(916) 481-5785

Amah/Mutsun Tribal Band
Melvin Ketchum III, Environmental Coordinator
7273 Rosanna Street — Ohlone/Costanoan
Gilroy , CA 95020
408-842-3220

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of the statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regard to cultural resources for proposed SCH# 2011062037 Recycled Water Project; Santa Clara County.

Native American Contact List
Santa Clara County
July 15, 2011

Muwekma Ohlone Indian Tribe of the SF Bay Area Rosemary Cambra, Chairperson 2574 Seaboard Avenue San Jose , CA 95131 muwekma@muwekma.org 408-205-9714 510-581-5194	Ohlone / Costanoan
Amah/MutsunTribal Band Jean-Marie Feyling 19350 Hunter Court Redding , CA 96003 **jmfgmc@sbcglobal.net** 530-243-1633	Ohlone/Costanoan
The Ohlone Indian Tribe Andrew Galvan PO Box 3152 Fremont , CA 94539 chochenyo@AOL.com (510) 882-0527 - Cell (510) 687-9393 - Fax	Ohlone/Costanoan Bay Miwok Plains Miwok Patwin
Linda G. Yamane 1585 Mira Mar Ave Seaside , CA 93955 rumsien123@yahoo.com 831-394-5915	Ohlone/Costanaon

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of the statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regard to cultural resources for proposed SCH# 2011062037 Recycled Water Project; Santa Clara County.

STATE OF CALIFORNIA—BUSINESS, TRANSPORTATION AND HOUSING AGENCY EDMUND G. BROWN, Jr., Governor

DEPARTMENT OF TRANSPORTATION
P.O. BOX 23660
OAKLAND, CA 94623-0660
PHONE (510) 286-5541
FAX (510) 286-5559
TTY 711

Flex your power!
Be energy efficient!

July 18, 2011

SCL-82/24.04, 101/52.17, 280/18.38
SCLVAR013
SCH# 2011062037

Ms. Clare Campbell
City of Palo Alto
250 Hamilton Avenue, 6th Floor
Palo Alto, CA 94301

Dear Ms. Campbell:

City of Palo Alto Recycled Water Project – Notice of Preparation (NOP)

Thank you for including the California Department of Transportation (Department) in the environmental review process for the proposed project. We have reviewed the NOP and have the following comments to offer.

Traffic Impact Study (TIS)
While the City conducts its traffic studies in accordance with guidelines, which conform to the local Congestion Management Program managed by the Santa Clara County Valley Transportation Authority, the Department's thresholds are primarily concerned with potential impacts to the State Highway System. We encourage the City to coordinate preparation of the study with our office to help sharpen the focus of your scope of work and answer any questions you may have. Please see the Department's "*Guide for the Preparation of Traffic Impact Studies*" at the following website for more information:
http://www.dot.ca.gov/hq/traffops/developserv/operationalsystems/reports/tisguide.pdf

Specifically, a detailed TIS should identify impacts to all affected state facilities with and without the proposed project. The TIS should include, but not be limited to the following:

1. Information on the project's traffic impacts in terms of trip generation, distribution, and assignment. The assumptions and methodologies used in compiling this information should be addressed.

2. Average Daily Traffic (ADT), AM and PM peak hour volumes on all significantly affected streets and highways, including crossroads and controlling intersections.

3. Schematic illustration of the traffic conditions for: 1) existing, 2) existing plus project, and 3) cumulative for the intersections in the project area.

4. Calculation of cumulative traffic volumes should consider all traffic-generating developments, both existing and future, that would affect the State Highway facilities being evaluated.

5. Mitigation measures should consider highway and non-highway improvements and services. Special attention should be given to the development of alternate solutions to circulation problems that do not rely on increased highway construction.

6. All mitigation measures proposed should be fully discussed, including financing, scheduling, implementation responsibilities, and lead agency monitoring.

7. Impacts to transit systems, pedestrians and bicyclists. Please develop and apply pedestrian bicycling and transit performance or quality of service measures and model pedestrian, bicycle and transit trips that your project will generate so that impacts and mitigation can be quantified. In addition, analyze secondary impacts on pedestrians and bicyclists that may result from any traffic impact mitigation measures. Describe any pedestrian and bicycle mitigation measures and safety countermeasures that would therefore be needed as a means of maintaining and improving access to transit facilities and reducing vehicle trips and traffic impacts on state highways.

We look forward to reviewing the TIS, ***including*** Technical Appendices and the environmental document for this project. Please send two copies to:

Brian Brandert
Office of Transit and Community Planning
Department of Transportation, District 4
P.O. Box 23660
Oakland, CA 94623-0660

Encroachment Permit

Work that encroaches onto the State ROW requires an encroachment permit that is issued by the Department. To apply, a completed encroachment permit application, environmental documentation, and five (5) sets of plans clearly indicating State ROW must be submitted to the address below. Traffic-related mitigation measures should be incorporated into the construction plans during the encroachment permit process.

Office of Permits
California DOT, District 4
P.O. Box 23660
Oakland, CA 94623-0660

See the website link below for more information.
http://www.dot.ca.gov/hq/traffops/developserv/permits/

Please feel free to contact Brian Brandert at (510) 286-5505, if you have any questions regarding this letter.

Sincerely,

GARY ARNOLD
District Branch Chief
Local Development-Intergovernmental Review

c: Scott Morgan (State Clearinghouse)

SANTA CLARA
Valley Transportation Authority

July 18, 2011

City of Palo Alto
Planning Department
P.O. Box 10250
Palo Alto, CA 94303

Attention: Clare Campbell

Subject: Palo Alto Recycled Water Project

Dear Ms. Campbell:

Santa Clara Valley Transportation Authority (VTA) staff have reviewed the Notice of Preparation for a Draft EIR for five miles of recycled water pipeline and pump stations in Central Palo Alto and Stanford University.

VTA provided comments on the Mitigated Negative Declaration for this project on April 16, 2009. Those comments are still applicable to the current environmental document and are attached for your use.

Thank you for the opportunity to review this project. If you have any questions, please call me at (408) 321-5784.

Sincerely,

Roy Molseed
Senior Environmental Planner

PA0901

SANTA CLARA
Valley Transportation Authority

April 16, 2009

City of Palo Alto
Planning Department
P.O. Box 10250
Palo Alto, CA 94303

Attention: Clare Campbell

Subject: Palo Alto Recycled Water Project

Dear Ms. Campbell:

Santa Clara Valley Transportation Authority (VTA) staff have reviewed the Mitigated Negative Declaration for 5 miles of recycled water pipeline and pump stations in central Palo Alto. We have the following comments.

Traffic Control Plan

VTA requests the opportunity to review the full traffic control plans when they become available in order to determine if there are potential impacts to CMP facilities during construction.

We also recommend a media campaign to notify the public about the duration of the construction, lane closures, and potential detour routes.

We recommend prohibiting construction before 9 a.m. and after 3 p.m. since the peak hour traffic on some of the CMP facilities in the area starts around 3.pm.

Impacts to Bus Service

Mitigation measure TRA-1 requires that damaged road surfaces be returned to pre-construction conditions or better. We assume this includes bus stop facilities also.

Once the final pipeline route is determined, VTA would like to review it to determine which bus routes and bus stops will be impacted.

VTA Contacts

If construction involves cutting through a VTA PCC bus stop pavement pad, a Construction Access Permit will be required and the project should include this requirement in the Special Conditions of the contract. The contractor should be directed to contact Debbie Dionne, Permits and Utility Locating Services, at (408) 321-5824.

If temporary relocation of bus stops is needed, the contractor should contact Steve Newgren at (408) 952-4106 at least 72 hours in advance.

Thank you for the opportunity to review this project. If you have any questions, please call me at (408) 321-5784.

Sincerely,

Roy Molseed
Senior Environmental Planner

RM:kh

cc: Samantha Swan, VTA

PA0901

July 14, 2011

VIA HAND DELIVERY

Clare Campbell, Planner
City of Palo Alto
250 Hamilton Avenue
Palo Alto, CA 94301

Re: Comments on NOP and Request For Special Notice
Recycled Water Project

Dear Ms. Campbell:

We are writing to ensure that the EIR the City is preparing for its recycled water project addresses the City's plans for implementing its Salinity Reduction Policy and all the impacts of using recycled water. We also want to ensure that the EIR addresses the extensive information Stanford has provided to the City on this subject.

Stanford agrees with the City's decision not to proceed with the initial study/mitigated negative declaration the City prepared earlier for this project, since that study omitted analysis of many impacts of use of high salinity recycled water. We are disappointed that the City has failed to fulfill its numerous promises to sit down with Stanford and discuss a solution to the salinity problem before moving forward with this project.

The fundamental problem with analysis of the project as proposed in the NOP is that it fails to address implementation of the Salinity Reduction Policy the Council adopted in January 2010. Studying the infrastructure to deliver recycled water without addressing the means the City will use to reduce the salinity of that recycled water piecemeals the project.

The EIR must address *all* impacts of use of recycled water at Stanford Research Park and all other foreseeable locations. These impacts include impacts on all landscaping, not just impacts to redwood trees. The EIR must address the soil conditions at Stanford Research Park and other foreseeable locations. The EIR must also study potential impacts before they happen, rather than deferring analysis until someone applies for an exemption after damage has occurred.

Stanford has invested substantial time and resources to clearly identify the critical factors contributing to the salinity problem. We have provided extensive materials to the City in connection with this project, some of which were prepared by the consultant the City is now using to provide supplemental analysis for the EIR. As it appears that the City has not yet used this information in addressing its recycled water proposal, we are providing copies of these materials again, as follows:

1. April 17, 2009 comment letter from Stanford

2. May 28, 2009 comment letter from Stanford, enclosing:
    - Designing Landscapes Using Recycled Water (HortScience)
    - Irrigation with Recycled Water in Santa Clara County: Limitations and Potentials (Oster)
    - Determining the Tolerance of Coast Redwood (Barnes et al.)
    - Email regarding redwoods and coast live oak (Nelda Matheny)
    - Safe Application of Reclaimed Water Reuse in the Southwestern United States (UC Davis)

3. October 16, 2009 letter to Council from Stanford

4. November 24, 2009 letter to Council from Stanford, enclosing a revised set of Recycled Water Quality Guidelines prepared by HortScience

We incorporate these enclosures into this letter, as official comments on the NOP. The EIR needs to address all this evidence, all our comments, and our proposals.

Stanford also requests special notice of all meetings, hearings, workshops and notices (including CEQA notices) related to this project. Please direct such notices to our attention.

Sincerely,

William T. Phillips /gyb

William T. Phillips
Senior Associate Vice President
Land, Buildings and Real Estate

Jim Inglis
Director of Design & Construction

cc: Nicolas Procos
Steve Emslie
Phil Bobel

STANFORD
UNIVERSITY

November 24, 2009

Ms. Valerie Fong
City of Palo Alto Utilities
250 Hamilton Avenue
Palo Alto, CA 94301

Re: Palo Alto Recycled Water Project: Updated HortScience Water Quality Guidelines for Salinity Impacts to Landscaping

Dear Ms. Fong:

Stanford University learned on Monday, November 23rd that City staff intends to submit a proposed salinity policy to the Utilities Advisory Commission for its consideration on Wednesday, December 2nd. To date, however, the City has not published the contents of its proposed policy, and as a result, Stanford has not had any opportunity to review the substance of the policy or to discuss it with City staff. Given the Thanksgiving holiday, we are concerned there will not be sufficient time after publication of the proposed policy and before the December 2nd UAC meeting to discuss meaningfully with staff any problems or issues that the policy may present. We may, therefore, be compelled to submit comments on the policy at or shortly before the meeting.

As we have previously documented, Stanford has serious concerns about the adverse effects on trees and plants at the Stanford Research Park from the use of high salinity irrigation water. In May 2009, we proposed a science-based solution to this problem, as set forth in the Recycled Water Quality Guidelines for the Stanford Research Park. The Guidelines were prepared by Nelda Matheny of HortScience and David Kelley of Kelley and Associates, two prominent experts in the field. The Guidelines are designed to protect redwoods and other salt-sensitive plantings that would be irreparably damaged from the use of recycled water with high salt content.

In anticipation of the upcoming UAC meeting, we have enclosed a revised set of Recycled Water Guidelines for consideration by City staff and the UAC. Please note that HortScience updated these Guidelines to provide for improved water quality categorization, an explanation of how to categorize water quality when constituents fall into multiple categories, corrected literature citations, an appendix of important terms, and improved clarity overall. The conclusion of the Guidelines remains the same as before: To avoid deleterious impacts to salt-sensitive plantings, steps must be taken to ensure that the recycled water used at the Stanford Research Park meets specified numeric criteria for various parameters of salinity.

STANFORD REAL ESTATE OFFICE
2755 Sand Hill Road, Suite 100 • Menlo Park, CA 94025 •T: 650.926.0300 • F: 650.854.9268

Stanford expects to continue working with its consultants and the City of Palo Alto to develop a science-based solution to ensure that the existing landscaping at the Research Park is preserved and that harmful effects on trees and plants are avoided. We, of course, remain committed to working cooperatively with the City to achieve a mutually beneficial resolution of the salinity issues posed by the use of recycled water.

Sincerely,

William T. Phillips
Senior Associate Vice President
Land, Buildings and Real Estate

Jim Inglis
Director of Design & Construction

Attachment: Nelda Matheny & David Kelley, *Water Quality Guidelines for Stanford Research Park* (2009)

cc: Phil Bobel – City of Palo Alto
Steve Emslie – City of Palo Alto
Nicolas Procos – City of Palo Alto
Jim Inglis – Stanford University
Bill Phillips – Stanford University
Jean Snider – Stanford University
Marc Bruner – Bingham McCutchen

Recycled Water Quality Guidelines for Stanford Research Park

Nelda Matheny, HortScience, Inc. and David Kelley, Kelley and Associates

Palo Alto's urban forest provides many environmental, aesthetic, economical, psychological, and social benefits to its citizens. Well-established plantings of the Stanford Research Park contribute to the value of Palo Alto's urban forest. Healthy and growing trees and other plants are vital to sustaining those benefits.

Irrigating landscapes with recycled water is an important component of California's efforts to conserve our water resources, and one that we wholeheartedly support when that resource is correctly applied and suitably managed. By applying recycled water to landscapes, potable water is conserved for human consumption.

Recycled water contains salts that, over time, can damage sensitive plants and degrade soil quality (Costello and others 2003, Harivandi 2000, Matheny and Clark 1998, Miyamoto 2008, Qian and Mecham 2005, Qian 2006, Tanji and others 2009, Wu and others 2009). Our goal is to ensure that the recycled water that is applied to our landscapes is of appropriate quality to maintain healthy trees and other plants. If we do not sustain our urban forests, we lose important environmental and economic benefits.

Evaluating response of landscapes to recycled water

The response of an existing landscape to irrigation with recycled water depends on the degree to which soil will become affected and the tolerance of plant materials to salts and specific ions. Evaluation of sites for irrigation with recycled water must consider water, plant, and site factors as well as irrigation management. There are several factors to consider when evaluating site suitability for irrigation with recycled water.

Water quality – The higher the water's salt concentration, the more likely plants will be injured and soils will be degraded.

Soil characteristics – As a rooting environment, soil holds the water and nutrient elements for root uptake. Some constituents in recycled water, such as sodium, can have negative effects on the soil and the plants as they concentrate over time. There are four soil characteristics of key importance.

Chemical characteristics – Well-buffered soils with low concentrations of salts can sequester and accommodate more salts from the water before salt concentrations cause plant damage.

Texture of the soil - Clay (fine-textured) soils are more quickly degraded by excess sodium than sandy (coarse-textured) soils.

Soil profile – The vertical gradation or layering with soil depth affects water percolation, salt accumulation, and plant rooting patterns.

Soil drainage - Soils with poor drainage characteristics accumulate salts and cannot be easily leached. The poorer the drainage, the better quality water required.

Salt-sensitivity of plants in the landscape. Plants vary widely in their tolerance or sensitivity to salts. Sodium-and boron-sensitive plants are less tolerant of recycled water than salt tolerant species.

Irrigation method and frequency. Many plants are injured at lower concentrations of sodium and chloride when water is applied to the foliage as opposed to the soil. Sensitive plantings irrigated by sprinklers require water lower in sodium and chloride to avoid injury. Drip irrigation emitters can become clogged by calcium carbonate precipitates and suspended solids when present in recycled water.

Drought stress occurs at higher soil moisture as water quality declines because salts increase the osmotic pressure of the soil water. As the soil dries, the salts in the soil solution become more concentrated and plant damage is more likely to occur. When using recycled water, irrigation frequency should be adjusted to maintain moist soil and leach accumulated salts below the root zone.

Site evaluation prior to applying recycled water to a landscape

The following are the basic components of a site assessment that should be performed before recycled water is introduced to the landscape. The results of these assessments are key to evaluating the impacts a given recycled water supply will have on the function and environmental benefits provided by the landscape, and will inform future landscape management activities.

1. Review USDA Natural Resources Conservation Service soil maps of the area.
2. Determine quality of water to be applied: maximum, minimum, and average annual values for electrical conductivity, chloride, sodium, boron, bicarbonate, and sodium adsorption ratio (SAR).
3. Inventory the plant species and evaluate likely response to the concentrations of sodium, chloride, and boron reported in the recycled water.
4. Identify locations for soil sampling and provide the following at each:

   a. Inspect and describe soil profiles of the root zone. Characterize soil texture, structure, layers, water table depth, redoximorphic features, drainage class, and other features.

   b. Collect and analyze soil samples at each sampling location from surface and subsurface. Analyses should include: pH, Ec_e (electrical conductivity, a measure of salinity), NO_3, NH_4, P, K, Ca, Mg, B, Cl, Na, SAR, mechanical analysis (texture).

5. Identify any constraints the plant palette, current plant condition, and soil characteristics may have on successful use of recycled water for irrigation.
6. Describe the likely short- and long-term effects irrigation with recycled water at the site will have on landscape appearance, health, and function.

It is important to complete these assessments before recycled water is introduced to the landscape rather than waiting until the water has been introduced and symptoms of salt problems have developed. Once salt-sensitive trees like redwoods have been damaged, the injury cannot be undone. It is much easier and more effective to prevent salt problems developing than try to correct them after they have occurred.

Water quality guidelines

FAO water quality guidelines (Ayers and Westcot 1985), which were developed for agricultural uses, commonly are applied to landscapes. Although agricultural cropping systems and landscapes have some characteristics in common, there are significant dissimilarities too. Landscapes are comprised of a wide range of species rather than a single crop, are planted in highly modified, variable, and often degraded soils rather than prime agricultural soil, and are long-lived rather than replanted each year. Furthermore, successful landscapes are judged by their appearance and function rather than by the amount of food or growth they produce.

We recommend evaluating water quality applied to landscapes based on the tolerance of the plant materials to salts in the specific water source and degree to which soil is expected to become degraded. Four categories of water quality are defined.

Category 1: Good water quality with no restrictions on site use.

Category 2: Moderate water quality that is appropriate for all landscapes except those with salt and/or boron sensitive plants and poorly drained soils that cannot be leached.

Category 3: Fair water quality that can be used where plants have at least moderate salt and/or boron tolerance and soils are at least moderately drained; landscapes on poorly drained sites must be comprised of plants with good salt and/or boron tolerance.

Category 4: Poor water quality that is appropriate only for sites having salt and/or boron tolerant plants and moderate to good drainage.

The poorer the water quality, the less suitable it is for use at sites with heavy soils and salt-sensitive plants (Table 1). For example, prolonged irrigation with Category 2, 3, or 4 water would damage salt sensitive species such as coast redwood (Oster 2009). Soils with complex structures (including compacted layers) and stratified horizons will respond differently to water application and throughflow, so permeability of the root zone is another factor affecting use and efficacy of recycled water used for irrigation.

Table 1: Water quality categories appropriate to sustain healthy landscapes as affected by soil texture, drainage, and plant sensitivity to salts.

See Table 2 for water quality guidelines.

Soil Texture/ Drainage	Plant Sensitivity to Salts		
	Sensitive	**Moderate**	**Tolerant**
Sandy, good drainage	Category 1 or 2	Category 1, 2, 3	Category 1, 2, 3, 4
Loam, good to moderately drained	Category 1 or 2	Category 1, 2, 3	Category 1, 2, 3, 4
Clay or poor drainage	Category 1	Category 1 or 2	Category 1, 2, 3

According to Grieve and others (2007), "It is not adequate only to identify maximum TDS or EC_w for use in landscapes containing salt-sensitive species; limits for sodium, chloride, boron, and RSC must also be established." Therefore, ranges for each of these components in each of the four water quality categories are identified in Table 2. These ranges were derived from a review of the scientific literature, as well as our experience over the last 20 years evaluating and analyzing soil, water, and tissue samples from landscape irrigated with recycled water.

Table 2: Interpretive guidelines for recycled water quality for landscape irrigation. See appendix for description of parameters.

Parameter	Category 1	Category 2	Category 3	Category 4
Salinity hazard[a]	None	Slight	Moderate	Severe
TDS, mg/l	<650[b,c]	650-1,000	1,000-2,000	>2,000
EC_w, dS/m	<1.0[f]	1.0-1.5	1.5-3	>3.0[i,]
Specific ion toxicity				
Boron (mg/l)	<0.5	0.5-1.0	1.0-3.0	>3.0[g,i]
Chloride (mg/l)[a,d,e]	<100	100-200	200-350	>350
Sodium (mg/l)[a,d,e]	<70	70-150	150-250	>250
Sodium adsorption ratio (SAR)[a,l,j]				
If SAR is:	and EC_w is[k]:			
0-3	>0.7	0.7-0.5	0.4-0.2	<0.2
3-6	>1.2	1.2-0.8	0.7-0.3	<0.3
6-12	>1.9	1.9-1.2	1.1-0.5	<0.5
12-20	>2.9	2.9-2.1	2.0-1.3	<1.3
Residual sodium carbonate (meq/l)[i]	<1.25	1.25-2.0	2.0-2.5	>2.5
Bicarbonate (mg/l)[a,i]	<90	90-200	200-500	>500
Residual chlorine (mg/l)[h,i]	<1.0	1-2.5	2.5-5.0	>5.0

[a]Morris and Devitt, 2002
[b]Oster 2009
[c]Barnes, Oki and Evans 2007
[d]Devitt and others 2005
[e]Myamoto and others 2004
[f]Miyamoto and others 2001
[g]Tanji and others 2007
[h]Cayanan and others 2008
[i]Ayers and Westcott 1985
[j]Harivandi 2004
[k]To use table, find SAR of water within ranges listed; along that line, identify the EC_w. The column in which the EC_w appears identifies the Category. For instance, if the SAR is 4 and the EC_w is 1.1, the SAR is in Category 2.

When assessing water quality it may be found that more than one category is represented. For instance, the salinity may place the water in Category 2; the SAR, in Category 1. In this case the highest, Category 2, would be used. Some parameters are more important than others, however. The parameters in Table 2 are listed in approximate order of importance: salinity and specific ions are most important, followed by SAR, and then by residual sodium carbonate and bicarbonate. If the water salinity were in Category 2 and the bicarbonate in Category 3, we suggest classifying the water in Category 2.

Establishing recycled water quality guidelines for Stanford Research Park

Wu and others (2009) stated that a necessary safeguard during the design of an urban reclaimed water distribution system is that, "The recycled water agency must assure that the reclaimed water delivered to the customer meets the water quality standards for the intended uses."

When new landscapes are designed that will be irrigated with recycled water, it is possible to create a landscape that will perform well when irrigated with recycled water. Stanford Research Park (SRP), however, is an established landscape comprised of a variety of types of plants having a range in salt tolerance from low to high.

In landscapes comprised of a variety of species, Wu and Guo (2006) indicated that, "…salt concentrations in recycled water must be acceptable for the most sensitive landscape plant species." For the SRP, coast redwood is a key landscape tree, and one that is sensitive to salt (Wu and Guo, 2006; Barnes et al., 2007). For the landscapes to remain healthy and functioning, salt concentrations in recycled water quality must not exceed the low salt tolerance threshold of redwoods. Oster (2009) recommended maintaining soil-water salinity levels between 1 and 2 dS/m for redwoods. He suggested that the salinity of the water not exceed 1 dS/m (approximately 640 ppm TDS).

Based on USDA Natural Resources Conservation Service soil survey maps and geotechnical reports prepared for several sites, we know that the soils at SRP are layered, with variable clayey fills present. Native soil textures range from clays and gravelly clays to clayey and silty sands and depths to bedrock vary. The soils were undoubtedly compacted during construction. From this information we estimate that the soils are at least moderately to somewhat poorly drained, with leaching potentials ranging from good to moderately poor.

Given our current knowledge of soil conditions at Stanford Research Park, and the presence of significant trees having low salt tolerance, we recommend that recycled water meet Category 1.

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Appendix

Total salts. Salinity is the most important measure of water quality for landscape plants. It is expressed as total dissolved solids (TDS) and electrical conductivity (EC_w). When water is applied to soils, some of the salts in the water (notably Na, Cl and B) remain in the soil. As these salts accumulate in the soil, plant toxicity may occur. Salt toxicity is first expressed as stunting of growth and yellowing of foliage. Burning of the edge of the leaves and defoliation usually follows. In severe cases, plants are killed. The degree of the problem depends on the sensitivity of the plant to salts and the concentration of the accumulated salts in the soil.

Specific ion toxicity. While salinity expresses the total salt content, it will not adequately identify potential toxicities from specific ions. Chloride (Cl), sodium (Na) and boron (B) concentrations in recycled water can and often do cause injury to sensitive plants. Boron in particular must be evaluated independently of other salts. It is toxic in such low concentrations (<1 ppm), that its presence will not be reflected in the general salinity measurement.

Sodium and chloride toxicity will occur at lower concentrations when the water is applied to the foliage (as with sprinklers) than when applied to the soil and absorbed through roots. Plant damage tends to be greatest when under high evapotranspiration conditions.

Sodium adsorption ratio. In addition to affecting plants directly, sodium can have negative effects on soil structure. It may cause dispersion of soil aggregates if present in high concentrations. This decreases both drainage and soil aeration which may cause plant decline and death. Soils high in clay are particularly susceptible to breakdown of aggregates by sodium.

Sodium hazard to soils is usually assessed from the sodium adsorption ratio (SAR), a value calculated from the sodium, calcium and magnesium concentrations. However, the permeability problems that can be caused by a high SAR can be partially offset by salts in the water. A more accurate measure of potential problems in irrigation water is the adjusted sodium adsorption ratio (adj R_{Na}) calculated from the salinity, bicarbonate, calcium, sodium and magnesium concentrations of the water.

Bicarbonate. Bicarbonate affects plants through its influence on pH and interaction with sodium. High bicarbonate can cause iron chlorosis symptoms in plants. Water high in bicarbonate, carbonate and calcium and/or magnesium can result in a white precipitate forming on foliage under sprinkler irrigation. Irrigation hardware is also susceptible to damage from bicarbonates. The precipitates can clog drip emitters.

High bicarbonate increases the effect of the available sodium in the water and its potential effect on sodium levels in the soil and plants. When bicarbonate combines with calcium or magnesium in soils, calcium carbonate and magnesium carbonate precipitate out. Consequently the SAR of the soil increases, and permeability to water may become a problem.

Residual sodium bicarbonate. The bicarbonate hazard to soils can be evaluated by calculating the residual sodium carbonate (RSC). The RSC is the sum of the carbonate and bicarbonate ions minus the sum of calcium and magnesium ions.

pH. pH is a unit of measure that describes the alkalinity or acidity of a solution. Negative log of the hydrogen ion concentration. It is measured on a logarithmic scale from 0 to 14. The pH of water affects metal solubility (e.g. Fe, Mn, Zn, Al) as well as alkalinity of soils.

Residual chlorine. Chlorine is commonly added to recycled water as a disinfectant. Excessive amounts of free available Cl (.0.05 mg/l Cl_2) may cause leaf-tip burn and damage sensitive plants when sprayed onto the foliage. However, most chlorine in recycled water is in a combined form, which does not cause plant damage.

STANFORD
UNIVERSITY

May 28, 2009

Ms. Valerie Fong
City of Palo Alto Utilities
250 Hamilton Avenue
Palo Alto, CA 94301

Re: Palo Alto Recycled Water Project: Proposed Water Quality Parameters for Salinity

Dear Ms. Fong:

Stanford University is submitting this letter in anticipation of the City Council hearing scheduled for Monday, June 1 on the draft Initial Study/Mitigated Negative Declaration ("IS/MND") for the Palo Alto recycled water project. Stanford would like to discuss with City staff a solution to address the project's effects on trees and plants resulting from the use of high-salinity irrigation water. Stanford will be submitting under separate cover a letter addressing the City's responses to comments on the IS/MND.

As Stanford documented in its April 17 comments on the IS/MND, the scientific record shows that without adequate controls, the use of recycled water from the Palo Alto Regional Water Quality Control Plant for irrigation purposes would cause serious harm to coastal redwood trees and other salt-sensitive species at the Stanford Research Park. To address this problem, Stanford has worked with its consultants to develop a solution to ensure that the existing landscaping at the Research Park is preserved and harmful effects on trees and plants are avoided. As explained below, this solution would augment the City's adaptive management program to ensure that irrigation use is limited to recycled water meeting specified numeric parameters for the constituents of concern.

Stanford is committed to working with the City to achieve a mutually beneficial solution to the salinity issues posed by the project. Such a solution requires objective, verifiable standards based on sound science, so that adverse effects on landscaping are prevented and minimized at the outset, instead of being addressed in response to damage from salinity only after it has occurred. Stanford's ultimate goal is to support the continued beneficial use of recycled water for irrigation, while ensuring that the health, function and appearance of existing landscaping are maintained.

To develop a science-based solution to the salinity problem, Stanford retained two established horticultural experts, Nelda Matheny and David Kelley, to formulate numeric water quality parameters for the relevant constituents in the irrigation water. The analysis of Ms. Matheny and Mr. Kelley, which is attached to this letter, evaluates the response of landscapes to recycled water, the relevant factors that need to be considered before using recycled water at a given site, the site-specific soil and plant conditions at the Stanford Research Park, and the water quality needed to sustain a healthy environment at the Research Park for redwoods and other salt-sensitive species. The analysis concludes that, in order to be safe for application at the Research Park given the soil conditions and plant species that are present, recycled water would need to meet the following parameters prior to irrigation use:

TDS	<640 mg/l
ECw	<1.0 dS/m
Boron	<0.75 mg/l
Chloride	<180 mg/l
Sodium	<120 mg/l
Residual sodium carbonate (RSC)	<2.5 meq/l
Bicarbonate (HCO3)	<200 mg/l
Residual Chlorine	<5 mg/l

Stanford accordingly proposes that the City incorporate the numeric parameters included in the attached scientific analysis into the City's adaptive management program. Stanford believes that compliance with these parameters, before recycled water is used for irrigation, is necessary to adequately protect plantings and ensure that the project's salinity impacts will not be significant.

The attached scientific analysis is still under refinement, and Stanford looks forward to working with City staff, prior to the public hearing on the project scheduled for July 6, to finalize the analysis and incorporate into the project specific parameters for irrigation use at the Stanford Research Park.

Stanford believes that its proposed solution achieves the mutually beneficial goals of protecting the environment, minimizing harm to trees, providing for the safe use of recycled water, and allowing Palo Alto's recycled water project to go forward and be successful in the long run. However, without proper controls on the use of recycled water, it is Stanford's position that the project will have significant, unmitigated environmental impacts that require further evaluation and public review under CEQA.

Stanford appreciates your consideration of these issues and looks forward to working with the City to resolve them.

Sincerely yours,

William T. Phillips
Senior Associate Vice President
Land, Buildings and Real Estate

Jim Inglis
Director of Design & Construction

Attachment: Nelda Matheny & David Kelley, *Proposed Water Quality Guidelines for Stanford Research Park* (May 27, 2009) (with attached resumes)

STANFORD REAL ESTATE OFFICE
2755 Sand Hill Road, Suite 100 · Menlo Park, CA 94025
T: 650.926.0300 · F: 650.854.9268

Recycled Water Quality Guidelines for Stanford Research Park
Nelda Matheny, HortScience, Inc. and David Kelley, Kelley and Associates
May 27, 2009

Palo Alto's urban forest provides many environmental, aesthetic, economical, psychological, and social benefits to its citizens. Well-established plantings of the Stanford Research Park contribute to the value of Palo Alto's urban forest. Healthy and growing trees and other plants are vital to sustaining those benefits.

Irrigating landscapes with recycled water is an important component of California's efforts to conserve our water resources, and one that we wholeheartedly support when that resource is correctly applied and suitably managed. By applying recycled water to landscapes, potable water is conserved for human consumption.

Recycled water contains salts that can damage sensitive plants and degrade soil quality, however. Our goal is to ensure that the recycled water that is applied to our landscapes is of appropriate quality to maintain healthy trees and other plants. If we do not sustain our urban forests, we lose important environmental and economic benefits.

Evaluating response of landscapes to recycled water
The response of an existing landscape to irrigation with recycled water depends on the degree to which soil will become affected and the tolerance of plant materials to salts and specific ions. Evaluation of sites for irrigation with recycled water must consider water, plant, and site factors as well as irrigation management. There are several factors to consider when evaluating site suitability for irrigation with recycled water.

Water quality – The poorer quality the water (i.e., the higher the salt concentration), the more likely plants will be injured and soils will be degraded.

Soil characteristics – As a rooting environment, soil holds the water and nutrient elements for root uptake. Some constituents in recycled water, such as sodium, can have negative effects on the soil and the plants as they concentrate over time. There are four soil characteristics of key importance.

Chemical characteristics – Well-buffered soils with low concentrations of salts can sequester and accommodate more salts from the water before salt concentrations cause plant damage.

Texture of the soil - Clay (fine-textured) soils are more quickly degraded by excess sodium than sandy (coarse-textured) soils.

Soil profile – The vertical gradation or layering with soil depth affects water percolation, salt accumulation, and plant rooting patterns.

Soil drainage - Soils with poor drainage characteristics accumulate salts and cannot be easily leached. The poorer the drainage, the better quality water required.

Salt-sensitivity of plants in the landscape. Plants vary widely in their tolerance or sensitivity to salts. Sodium-and boron-sensitive plants have less tolerance to use of recycled water than do more salt tolerant species.

Irrigation method and frequency. Plants are more prone to sodium and chloride toxicity when water is applied to the foliage as opposed to the soil. Sensitive plantings irrigated by sprinklers require water lower in sodium and chloride. Drip irrigation emitters can become clogged by calcium carbonate precipitates and suspended solids in the water.

Drought stress occurs at higher soil moisture as water quality declines because salts increase the osmotic pressure of the soil water. When using poor quality water, irrigation frequency should be increased to maintain a moist soil if permeability and drainage factors are favorable. As the soil dries, the salts in the soil solution become more concentrated and plant damage is more likely to occur.

Site evaluation prior to applying recycled water to a landscape

The following are the basic components of a site assessment that should be performed before recycled water is introduced to the landscape. The results of these assessments are key to evaluating the impacts a given recycled water supply will have on the function and environmental benefits provided by the landscape, and will inform future landscape management activities.

1. Review USDA Natural Resources Conservation Service soil maps of the area.
2. Determine quality of water to be applied: Maximum, minimum, and average annual values for electrical conductivity, chloride, sodium, boron, bicarbonate, SAR.
3. Inventory the plant species and evaluate their likely response to the concentrations of sodium, chloride, and boron reported in the recycled water.
4. Identify locations for soil sampling and provide the following at each:

   a. Inspect and describe soil profiles of the root zone. Characterize soil texture, structure, layers, water table depth, redoximorphic features, drainage class, etc.

   b. Collect and analyze soil samples at each sampling location from surface and subsurface. Analyze for pH, Ec_e, NO_3, NH_4, P, K, Ca, Mg, B, Cl, Na, SAR, mechanical analysis (texture).

5. Identify any constraints the plant palette, current plant condition, and/or soil characteristics may have on successful use of recycled water for irrigation.

6. Describe the short- and long-term effects irrigation with recycled water at the site is likely to have on landscape appearance, health, and function

It is important to complete these assessments before recycled water is introduced to the landscape rather than waiting until the water has been introduced and symptoms of salt problems have developed. Once salt-sensitive trees like redwoods have been damaged by salt, the injury cannot be undone. It is much easier and more effective to prevent salt problems developing than try to correct them after they have occurred.

Establishing recycled water quality guidelines for Stanford Research Park
Wu *et al.* (2009) stated that a necessary safeguard during the design of an urban reclaimed water distribution system is that, "The recycled water agency must assure that the reclaimed water delivered to the customer meets the water quality standards for the intended uses."

When new landscapes are designed that will be irrigated with recycled water, it is possible to create a landscape that will perform well when irrigated with recycled water. Stanford Research Park (SRP), however, is an established landscape comprised of a variety of types of plants having a range in salt tolerance from low to high.

In landscapes comprised of a variety of species, Wu and Guo (2005) indicated that, "...salt concentrations in recycled water must be acceptable for the most sensitive landscape plant species." For the SRP, coast redwood is a key landscape tree, and one that is sensitive to salt (Wu and Guo, 2005; Barnes et al., 2007). For the landscapes to remain healthy and functioning, salt concentrations in recycled water quality must not exceed the low salt tolerance threshold of redwoods. Oster (2009) recommended maintaining soil-water salinity levels between 1 and 2 dS/m for redwoods. He suggested that the salinity of the water not exceed 1 dS/m (approximately 640 ppm TDS).

Based on USDA Natural Resources Conservation Service soil survey maps and geotechnical reports prepared for several sites, we know that the soils at SRP are layered, with variable clayey fills present. Native soil textures range from clays and gravelly clays to clayey and silty sands and depths to bedrock may be variable. The soils were undoubtedly compacted during construction. From this information we estimate that the soils are at least moderately to somewhat poorly drained, with leaching potentials ranging from good to moderately poor.

FAO water quality guidelines (Ayers and Westcot 1985), which were developed for agricultural uses, have been used to evaluate water quality. Application of those guidelines to landscapes has been difficult because of the dissimilarities between agricultural cropping systems and horticultural landscapes. Landscapes are comprised of a wide range of species, are planted in highly modified, variable, and often degraded soils, and are long-lived rather than replanted each year.

Water quality categories

Because the quality of recycled water that can be used at a site depends on the degree to which soil will become degraded and the tolerance of the plant materials to salts, four categories of water quality are defined.

Category 1: Excellent water quality with no restrictions on site use.

Category 2: Good water quality that is appropriate for all landscapes except those with salt and boron sensitive plants and poorly drained soils that cannot be leached.

Category 3: Fair water quality that can be used where plants have at least moderate salt and boron tolerance and soils are at least moderately drained; landscape vegetation on poorly drained sites must be comprised of plants with good salt and boron tolerance.

Category 4: Poor water quality that is appropriate only for sites having salt and boron tolerant plants and moderate to good drainage.

The poorer the water quality, the less suitable it is for use at sites with heavy soils and salt-sensitive plants (Table 1). Given our current knowledge of soil conditions at Stanford Research Park, and the presence of significant trees having low salt tolerance, we recommend that recycled water meet Category 1 or 2 quality guidelines. It is our opinion that prolonged irrigation with Category 3 or 4 water would damage salt sensitive species such as coast redwood.

Table 1: Water quality categories appropriate to sustain healthy landscapes as affected by soil texture, drainage, and plant sensitivity to salts.

See Table 2 for water quality guidelines.

Soil Texture/ Drainage	**Plant Sensitivity to Salts**		
	Sensitive	**Moderate**	**Tolerant**
Sandy, good drainage	Category 1 or 2	Category 1, 2, 3	Category 1, 2, 3, 4
Loam, good to moderately drained	Category 1 or 2	Category 1, 2, 3	Category 1, 2, 3, 4
Clay or poor drainage	Category 1	Category 1 or 2	Category 1, 2, 3

Soils with complex structures (including compacted layers) and stratified horizons will respond differently to water application and throughflow, so permeability of the root zone is another factor affecting use and efficacy of recycled water used for irrigation.

According to Grieve and others (2009), "It is not adequate only to identify maximum TDS or EC_w for use in landscapes containing salt-sensitive species; limits for sodium, chloride, boron, and RSC must also be established." Therefore, ranges for each of these components in each of the four water quality categories are identified in Table 2. These ranges were derived from a review of the literature listed in the references, as well as our experience over the last 20 years evaluating and analyzing soil, water, and tissue samples from landscape irrigated with recycled water.

Table 2: Interpretive guidelines for recycled water quality for landscape irrigation.

Species vary in tolerance to water quality. The poorer the water, the more severe are restrictions on use.

	Recycled water quality for landscape irrigation			
Parameter	**Category 1**	**Category 2**	**Category 3**	**Category 4**
Salinity				
TDS, mg/l	<450	450-640	640-1,000	>1,000
EC_w, dS/m	<0.7	0.7-1.0	1-1.5	>1.5
Specific ion toxicity				
Boron (mg/l)	<0.5	0.5-0.75	0.75-1.0	>1.0
Chloride (mg/l)	<100	100-180	180-300	>300
Sodium (mg/l)	<70	70-120	120-200	>200
Residual sodium carbonate (meq/l)	<1.25	1.25-2.5	>2.5	>2.5
Bicarbonate (mg/l)	<90	90-200	200-500	>500
Residual chlorine (mg/l)	<1	1-5	>5	

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NELDA MATHENY
CURRICULUM VITAE

HortScience, Inc.
2150 Rheem Dr., Suite A
Pleasanton CA 94588
(925) 484-0211

Summary of Qualifications

Ms. Matheny is founder and president of HortScience, Inc., a horticultural consulting firm. She specializes in tree evaluation and management, problem diagnosis and landscape suitability assessment. She has particular experience in tree preservation during land development and tree risk assessment and management. She is recognized for her extensive knowledge and experience in site evaluation, soils and recycled water use in landscapes.

Nelda has been instrumental in developing tree management programs for a variety of public agencies and private companies. She has developed methodology for tree risk assessments. She has provided training in tree risk management and preservation during development throughout the U.S., Great Britain, Italy, Canada and Australia.

Nelda is a Board Certified Master Arborist (WE-0195B) and a Registered Consulting Arborist (ASCA #243).

Certifications: Board Certified Master Arborist, #WE-0195B
Registered Consulting Arborist (ASCA #243)

Education: B.S. degree, Plant Science, Univ. of Calif., Davis, 1978
M.S. degree, Horticulture, Univ. of Calif. Davis, 1980

Experience: 1983 -- present, President, HortScience, Inc., a horticultural consulting firm providing problem diagnosis, tree preservation, landscape appraisals, and vegetation evaluation and monitoring, tree hazard assessment, landscape management programs.

1981 - 1983, Horticultural Consultant, Fruit Growers Laboratory, Inc., Santa Paula CA, a soil and plant tissue analysis lab.

1979 - 1981, Horticultural Consultant. Dean, Newman and Assoc., Westlake Village CA. Evaluated native trees and prepared tree preservation plans.

Professional activities: Trustee, The Britton Fund, Western Chapter International Society of Arboriculture. 2006-present.
Member, I.S.A. Board Certified Master Arborist Committee, 2004-present; currently Chairperson.
Chair, Research Committee, Western Chapter I.S.A. 2002-2004.
Member, International Society of Arboriculture Research Trust, Board of Trustees. Vice Chair. Chair of Research Committee. 1992 - 1995.
Member California Urban Forestry Advisory Council, 1992 - 1993.

Member, Water Use Classification of Landscape Plants (WUCOLS). California Dept. of Water Resources. 1992-1993.

Honors and Awards:

Alex Shigo Award for Arboricultural Education. International Society of Arboriculture. 2007.
Award of Merit. Western Chapter International Society of Arboriculture. 2006.
Award of Merit. United Kingdom & Ireland Chapter, International Society of Arboriculture, 2005
Award of Merit. International Society of Arboriculture. 2000.
Author's Citation. International Society of Arboriculture. 1998.
Research Award. Western Chapter International Society of Arboriculture. 1993.
President's Award. Western Chapter International Society of Arboriculture. 1993.

***Publications*:**

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Clark, J. and N. Matheny. 1994. The Special Needs of Trees. *In*: *IPM for Turf and Landscape*. A. Leslie, ed. Lewis Publishers/CRC Press. Boca Raton FL. pp17 - 28.

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N. Matheny. 1989. Preserving trees affected by development. In: *A Technical Guide to Community and Urban Forestry in Washington, Oregon and California*. World Forestry Center, pp. 34-41.

AREAS OF EXPERTISE

- Soil Science and Soil Geomorphology
- Agricultural Capability Assessment
- Arboricultural Assessment
- Ecological Restoration
- Wetlands Assessment and Delineation
- Mining and Disturbed Land Reclamation
- Environmental Planning andCompliance
- Habitat Evaluation and Conservation
- Biological Resource Management
- Wetlands Mitigation and Monitoring
- Range and Watershed Management
- International Agricultural Development

EDUCATION

Ph.D. Candidate,
Plant Physiology/Soil Science
University of California, Davis

M.Sc., Botany
Texas Tech University, 1974

B. Sc., Zoology
Texas Tech University, 1970

RESEARCH SCIENTIST/LECTURER

Soil, Plant, and Water Science
University of California, Davis
University Extension
1974 - 2003

Botany, Zoology, Range Science
Texas Tech University
1969 - 1974

REGISTRATIONS/CERTIFICATIONS

Certified Professional Wetlands Scientist #748
Society of Wetlands Scientists

Professional Soil Scientist #123
Professional Soil Scientists Association of California

BIOGRAPHICAL STATEMENT

David B. Kelley is founder and president of Kelley & Associates Environmental Sciences, Inc., an earth, environmental, and agricultural sciences consulting firm and of Tuscan, Incorporated, a non-profit wildlands management organization. He has been a consultant on soils, land use, arboriculture, environmental resource issues, and rangeland and agricultural matters for over 25 years. He is a registered professional soil scientist, a certified professional wetlands scientist, and a consulting arborist and range scientist. Mr. Kelley has been directly responsible for numerous large-scale agricultural and environmental assessment projects as well as tree, rangeland, and wildland resource surveys and environmental constraints analyses. He has special interests in tree and soil relationships, wetland systems (especially vernal pools and riparian systems), soil science and geomorphology, agricultural assessment and development projects, land use issues and analyses, and environmental restoration. As a professional plant and soil scientist and arborist, Mr. Kelley performs specialized analyses of arboricultural issues, agricultural land assessments, wetland systems, range and timberland restoration, and vegetation management, and is a specialist in working with disturbed sites. He is a court-qualified expert witness and litigation consultant on soils, trees, and land use issues, and has had career-long involvement as a wetland scientist and consulting soil scientist/agronomist and agricultural land assessment expert for projects in North, Central, and South America (including Mexico, Belize, Guatemala, Venezuela, Ecuador, Peru, and much of the United States) and Southeast Asia (Hong Kong and the Philippines). He is often involved in litigation consultation, analyses, and testimony on tree and soil issues, land resource interpretations, wetlands and wetland soils, rangelands, and orchard and field crop problems.

Mr. Kelley's agricultural work has involved working with growers and the agricultural/rangeland industry throughout California, especially in the Central Valley, the Salinas Valley, and the central and southern coastal zones. Other clients have included environmental, water, and land-use attorneys; city, state, and federal governments and agencies; developers and environmental groups; miners, farmers, and ranchers; and engineers, appraisers, and design professionals. He has developed and teaches training courses for private- and public-sector agriculture and biology professionals and has prepared several books and publications for those classes

In addition to designing and implementing several large-scale environmental restoration projects in urban and agricultural settings, Mr. Kelley is a specialist in the relationships of trees and soils; soil science and soil geomorphology; and in most aspects of wetland delineations, agricultural development projects, and regulatory permitting. He has permitted many mitigation projects designed to compensate for impacts to wetlands and other natural resources and has been directly responsible for numerous resource surveys and environmental constraints analyses. Among other projects, his firm has created a large off-site vernal pool wetlands mitigation preserve in Butte County, encompassing natural and created vernal pools and plantings of an endangered species of vernal pool plant; designed, permitted, and developed as a mitigation project a 254-acre preserve in Yolo County incorporating a large oxbow lake built as mitigation for loss of riparian habitat on the Sacramento River; designed restoration/reclamation plans for several sand and gravel mines in northern California; designed a native plant community/endangered species habitat restoration effort for a marina and roadway project in southern California; and performed resource surveys and mitigation planning for projects ranging in size from 2 to 12,700 acres throughout California.

He is an officer in several professional organizations and participates in short courses and meetings of those groups. Many of his projects have involved working closely with professional colleagues with complementary talents, or finding appropriate resource professionals to undertake complex jobs requiring teamwork and multi-disciplinary approaches.

REPRESENTATIVE EXPERIENCE

Wetlands Assessment & Delineation

- **Carriage Park Development Project, Ashington Corporation, San Jose, CA.** Wetlands delineation, soil resource assessment, and mitigation design for 200+ acre residential development in Chico, California.
- **M&T Ranch Gravel Mine, Knife River Corporation, Bismarck, ND.** Environmental assessment and reclamation planning for 300-acre mining project.
- **Wetland Assessments—Washington, Oregon, Nevada, Texas, Montana, Hawaii, and other states.**
- **Wetland Assessments--San Diego, Orange, Los Angeles, San Luis Obispo, Monterey, San Benito, Santa Clara, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte, and other Coastal California Counties.** Coastal California wetland delineations and permitting for many clients.
- **Wetland Assessments—Sacramento, Yolo, Butte, Placer, Solano, Napa, San Joaquin, Merced, Madera, Fresno, Kern, and other Central Valley Counties.** Wetland delineations and permitting for many clients of the Central Valley.

Natural Resources Planning/Resource Assessments

- **Pebble Beach Golf Course and Residential Development, Pebble Beach Company.** Soil, biological, and wetland resource assessment.
- **Cameron Park Pipeline Restoration, Beak, Inc./M. Green.** Restoration design and resource assessment.
- **Butte County Mitigation Bank Restoration, CNLM/M. Green.** Department of Fish and Game streamside riparian restoration project.
- **Morrison Creek Restoration, Sacramento Concrete/Dowd.** Riparian resource survey and restoration planning for mitigation.
- **Putah Creek Vegetation Surveys, HortScience, Inc./Matheny.** Resource surveys and habitat design.
- **Lighthouse Point, Santa Cruz, Restoration Design, Backhaus Landscape Architects.** Resource assessment and design for natural areas.

Agricultural Projects

- **Gilroy Land Conversion Project, EMC Planning Group, Inc.** Soils capability/agricultural viability assessment for MVW Properties, Gilroy, California.
- **San Benito County Agricultural Land Assessment, Piini Ranch.** Land capability assessment.
- **Salinas Land Capability Assessment, Rush, Marcroft Associates.** Land capability assessment.
- **Carneros District Vineyard Soil Salinity Problems, B. Ward.** Soil and site assessment.
- **Ica, Peru Asparagus Production, Couture Farms.** Agricultural development and land use management of 2500+ acres in Ica, Peru.
- **Northern Salinas Valley, Soil and Water Assessment, T&A, Inc.** Assessment of soil and water resources and irrigation supplies.

Biological Assessment/Mitigation

- **Butte County/Highway 49, Caltrans.** Butte County Meadowfoam survey
- **Scotts Valley/Glenwood Development Project, Ashington Corporation.** Biological survey and wetlands assessment; Mitigation planning for a residential development and school in Scotts Valley, California.
- **Coalinga Asbestos Mine Reclamation, Southern Pacific Land Company.** Asbestos mine/mill site biological survey; reclamation/revegetation analysis, and wetlands delineation near Coalinga, California.

Soils/Site Assessment

- **Morgan Hill Recharge Facility, Santa Clara Valley Water District.** Soil assessment for Draft Supplemental Initial Study for spoil emplacement site at Morgan Hill Recharge Facility in Santa Clara County, California.
- **San Jose Soil Assessment, Santa Clara Valley Water District.** Soils and site assessment at mitigation planting site on Guadalupe River in Santa Clara County, California.
- **Guadalupe Gardens, San Jose, Soil Assessment, HortScience, Inc.** Soils assessment and investigation for Guadalupe Gardens in San Jose, CA., and for Hacienda Business Park in Pleasanton, California.
- **Petaluma Soil and Wetland Investigation, Zentner & Zentner.** Soils investigation along Thompson Creek for proposed Westridge subdivision, Petaluma, California.
- **Putah Creek Resource Assessment, Solano County Water Agency.** Vegetation and soil survey; riparian habitat assessment, and management plan development for Putah Creek, Yolo County, California

REPRESENTATIVE EXPERIENCE (Continued)

Restoration & Revegetation

- **Malibu, Los Angeles County Ranch Restoration, Cardoso Family Trust.** Horse ranch restoration, horticulture plan, and water quality protection plan.
- **Paradise Marsh Revegetation Project. Community Development Commission of the City of National City, San Diego County, CA.** Marsh and upland biological resource survey and habitat restoration.
- **Yolo County Habitat Restoration, Lighthouse Marina and Riverbend Development.** Soil resource inventory, riparian and wetland restoration and mitigation on 284 acres in Yolo County and West Sacramento (Kachituli Oxbow project).
- **San Benito County Revegetation Plan, County of San Benito.** Revegetation plan assessment for Granite Rock Mining Project at Brigantino, San Benito County, California.
- **Petaluma Riparian Restoration Assessment, City of Petaluma.** Review and analysis of revegetation plan for 100+ acre Thompson Creek Restoration/Riparian Enhancement Project.

Mining and Reclamation

- **M&T Aggregate Mining Project, Knife River Corporation, Bismarck, ND.** Gravel mining feasibility study on 300 acres in Chico, California.
- **Decker Island Resource Survey and Reclamation Planning, Mega Sand, Inc., Antioch, CA.** Geologic and soils survey; mining and revegetation plan and floristic survey of 658-acre disturbed area of Decker Island Mining Project, Sacramento River Deep Water Channel, California
- **Randsburg Soil Resource Survey, Rand Mining Company.** Soil resource inventory/assessment and determination of site revegetation possibilities for 532-acre Baltic Mine Project, Randsburg, California.

INTERNATIONAL PROJECTS

- **Hong Kong Soils and Wetland Assessment, Kowloon-Canton Railroad Company**. Wetland impacts litigation.
- **Mindanao, Philippines, Asparagus Losses Litigation, Rush, Marcroft, Inc.** Crop damages.
- **Belize Agricultural Development, DeVaney Land Company**. Crop and land development.
- **Dominican Republic Agricultural Development, IRI Research Institute**. Sugar diversification.
- **Ecuador Vegetable Crop Development, A. Hall**. Crop development.
- **Baja California Sur, Mexico, New Zealand Gourmet**. Crop assessment and land development.
- **Ica, Peru, Asparagus production, Couture Farms**. Agricultural development and crop export.
- **Trujillo Asparagus, Agency for International Development**. Agricultural assessment.
- **Tunisia Agricultural Development, H. Hoelscher**. Saline soil remediation and crop development.
- **Venezuela Asparagus Production, R. Percivale.** Agricultural development.

OTHER RELEVANT EXPERIENCE

EXPERT WITNESS. Court-qualified expert witness and litigation consultant with a career-long involvement as a soils expert, an arborist, a wetland scientist, and consulting soil scientist/agronomist and agricultural land assessment expert. Projects have included work in North, Central, and South America (including Mexico, Belize, Guatemala, Venezuela, Ecuador, Peru, and much of the United States) and Southeast Asia (Hong Kong and the Philippines). Testimony as an expert witness has included soil characteristics and origin, soil losses and stability, soil erosion, soil and plant issues involving tree failures, tree roots and infrastructure damage, wetlands and endangered species, agricultural damages and losses, soil capability and land resource management, and related subjects.

TEACHER. Frequent presentations to scientific societies and congresses on soils and land use assessment, wetland science and environmental restoration, mine reclamation, tree and orchard problems, range science, soil geomorphology, soil and water conservation, watershed management, and agricultural science. Numerous seminars for attorneys, insurance companies, developers, and public agencies on wetland delineation and permitting, environmental restoration, natural hazards, soil and water quality issues, toxic wastes, reclamation/revegetation of disturbed sites, erosion control, vegetation management, and conservation issues. Teacher and coordinator of professional plant and soil science short courses on natural and agricultural resource topics – soil science and geomorphology, ecological restoration, trees and soils, wetland science, expert witness and litigation consultation, agricultural soil and land capability, erosion control, agricultural development, environmental regulation, stream restoration, watershed management, and other subjects.

LANGUAGE PROFICIENCY

- English
- Spanish

PROFESSIONAL AFFILIATIONS

American Geophysical Union
American Quarternary Association
American Society of Agronomy
American Society of Consulting Arborists
Association of State Wetlands Managers
California Native Grasslands Association
California Native Plant Society
California Urban Forest Council
Friends of the Arboretum/University of California, Davis
Friends of the Biological Sciences Herbarium, California State University, Chico
Geological Society of America
International Erosion Control Association
International Society of Arboriculture
National Audubon Society
National Society of Consulting Soil Scientists
National Watershed Coalition
Northern California Botanists
Professional Soil Science Association of California
Society for Ecological Restoration
Society for Range Management
Society of Wetland Scientists
Soil and Water Conservation Society
Texas Tech University Student Association
The Wildlife Society
Tree Davis
University of California-Davis Alumni Association
Watershed Management Council
Western Society of Soil Science
Yuba Watershed Institute

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CONTACT INFORMATION

DAVID B. KELLEY
CONSULTING PLANT AND SOIL SCIENTIST
PRESIDENT
K&AES, INC.
216 F STREET #51
DAVIS, CALIFORNIA 95616
TEL: 530-753-1232
FAX: 530-753-2935
E-MAIL: dbkelley@jps.net

Recycled Water Quality Guidelines for Stanford Research Park

Nelda Matheny, HortScience, Inc. and David Kelley, Kelley and Associates

May 27, 2009

Palo Alto's urban forest provides many environmental, aesthetic, economical, psychological, and social benefits to its citizens. Well-established plantings of the Stanford Research Park contribute to the value of Palo Alto's urban forest. Healthy and growing trees and other plants are vital to sustaining those benefits.

Irrigating landscapes with recycled water is an important component of California's efforts to conserve our water resources, and one that we wholeheartedly support when that resource is correctly applied and suitably managed. By applying recycled water to landscapes, potable water is conserved for human consumption.

Recycled water contains salts that can damage sensitive plants and degrade soil quality, however. Our goal is to ensure that the recycled water that is applied to our landscapes is of appropriate quality to maintain healthy trees and other plants. If we do not sustain our urban forests, we lose important environmental and economic benefits.

Evaluating response of landscapes to recycled water

The response of an existing landscape to irrigation with recycled water depends on the degree to which soil will become affected and the tolerance of plant materials to salts and specific ions. Evaluation of sites for irrigation with recycled water must consider water, plant, and site factors as well as irrigation management. There are several factors to consider when evaluating site suitability for irrigation with recycled water.

> ***Water quality*** – The poorer quality the water (i.e., the higher the salt concentration), the more likely plants will be injured and soils will be degraded.
>
> ***Soil characteristics*** – As a rooting environment, soil holds the water and nutrient elements for root uptake. Some constituents in recycled water, such as sodium, can have negative effects on the soil and the plants as they concentrate over time. There are four soil characteristics of key importance.
>
>> **Chemical characteristics** – Well-buffered soils with low concentrations of salts can sequester and accommodate more salts from the water before salt concentrations cause plant damage.
>>
>> **Texture of the soil -** Clay (fine-textured) soils are more quickly degraded by excess sodium than sandy (coarse-textured) soils.
>>
>> **Soil profile** – The vertical gradation or layering with soil depth affects water percolation, salt accumulation, and plant rooting patterns.

Soil drainage - Soils with poor drainage characteristics accumulate salts and cannot be easily leached. The poorer the drainage, the better quality water required.

Salt-sensitivity of plants in the landscape. Plants vary widely in their tolerance or sensitivity to salts. Sodium-and boron-sensitive plants have less tolerance to use of recycled water than do more salt tolerant species.

Irrigation method and frequency. Plants are more prone to sodium and chloride toxicity when water is applied to the foliage as opposed to the soil. Sensitive plantings irrigated by sprinklers require water lower in sodium and chloride. Drip irrigation emitters can become clogged by calcium carbonate precipitates and suspended solids in the water.

Drought stress occurs at higher soil moisture as water quality declines because salts increase the osmotic pressure of the soil water. When using poor quality water, irrigation frequency should be increased to maintain a moist soil if permeability and drainage factors are favorable. As the soil dries, the salts in the soil solution become more concentrated and plant damage is more likely to occur.

Site evaluation prior to applying recycled water to a landscape

The following are the basic components of a site assessment that should be performed before recycled water is introduced to the landscape. The results of these assessments are key to evaluating the impacts a given recycled water supply will have on the function and environmental benefits provided by the landscape, and will inform future landscape management activities.

1. Review USDA Natural Resources Conservation Service soil maps of the area.
2. Determine quality of water to be applied: Maximum, minimum, and average annual values for electrical conductivity, chloride, sodium, boron, bicarbonate, SAR.
3. Inventory the plant species and evaluate their likely response to the concentrations of sodium, chloride, and boron reported in the recycled water.
4. Identify locations for soil sampling and provide the following at each:

   a. Inspect and describe soil profiles of the root zone. Characterize soil texture, structure, layers, water table depth, redoximorphic features, drainage class, etc.

   b. Collect and analyze soil samples at each sampling location from surface and subsurface. Analyze for pH, Ec_e, NO_3, NH_4, P, K, Ca, Mg, B, Cl, Na, SAR, mechanical analysis (texture).
5. Identify any constraints the plant palette, current plant condition, and/or soil characteristics may have on successful use of recycled water for irrigation.

6. Describe the short- and long-term effects irrigation with recycled water at the site is likely to have on landscape appearance, health, and function

It is important to complete these assessments before recycled water is introduced to the landscape rather than waiting until the water has been introduced and symptoms of salt problems have developed. Once salt-sensitive trees like redwoods have been damaged by salt, the injury cannot be undone. It is much easier and more effective to prevent salt problems developing than try to correct them after they have occurred.

Establishing recycled water quality guidelines for Stanford Research Park

Wu *et al.* (2009) stated that a necessary safeguard during the design of an urban reclaimed water distribution system is that, "The recycled water agency must assure that the reclaimed water delivered to the customer meets the water quality standards for the intended uses."

When new landscapes are designed that will be irrigated with recycled water, it is possible to create a landscape that will perform well when irrigated with recycled water. Stanford Research Park (SRP), however, is an established landscape comprised of a variety of types of plants having a range in salt tolerance from low to high.

In landscapes comprised of a variety of species, Wu and Guo (2005) indicated that, "...salt concentrations in recycled water must be acceptable for the most sensitive landscape plant species." For the SRP, coast redwood is a key landscape tree, and one that is sensitive to salt (Wu and Guo, 2005; Barnes et al., 2007). For the landscapes to remain healthy and functioning, salt concentrations in recycled water quality must not exceed the low salt tolerance threshold of redwoods. Oster (2009) recommended maintaining soil-water salinity levels between 1 and 2 dS/m for redwoods. He suggested that the salinity of the water not exceed 1 dS/m (approximately 640 ppm TDS).

Based on USDA Natural Resources Conservation Service soil survey maps and geotechnical reports prepared for several sites, we know that the soils at SRP are layered, with variable clayey fills present. Native soil textures range from clays and gravelly clays to clayey and silty sands and depths to bedrock may be variable. The soils were undoubtedly compacted during construction. From this information we estimate that the soils are at least moderately to somewhat poorly drained, with leaching potentials ranging from good to moderately poor.

FAO water quality guidelines (Ayers and Westcot 1985), which were developed for agricultural uses, have been used to evaluate water quality. Application of those guidelines to landscapes has been difficult because of the dissimilarities between agricultural cropping systems and horticultural landscapes. Landscapes are comprised of a wide range of species, are planted in highly modified, variable, and often degraded soils, and are long-lived rather than replanted each year.

Water quality categories

Because the quality of recycled water that can be used at a site depends on the degree to which soil will become degraded and the tolerance of the plant materials to salts, four categories of water quality are defined.

Category 1: Excellent water quality with no restrictions on site use.

Category 2: Good water quality that is appropriate for all landscapes except those with salt and boron sensitive plants and poorly drained soils that cannot be leached.

Category 3: Fair water quality that can be used where plants have at least moderate salt and boron tolerance and soils are at least moderately drained; landscape vegetation on poorly drained sites must be comprised of plants with good salt and boron tolerance.

Category 4: Poor water quality that is appropriate only for sites having salt and boron tolerant plants and moderate to good drainage.

The poorer the water quality, the less suitable it is for use at sites with heavy soils and salt-sensitive plants (Table 1). Given our current knowledge of soil conditions at Stanford Research Park, and the presence of significant trees having low salt tolerance, we recommend that recycled water meet Category 1 or 2 quality guidelines. It is our opinion that prolonged irrigation with Category 3 or 4 water would damage salt sensitive species such as coast redwood.

Table 1: Water quality categories appropriate to sustain healthy landscapes as affected by soil texture, drainage, and plant sensitivity to salts.

See Table 2 for water quality guidelines.

Soil Texture/ Drainage	Plant Sensitivity to Salts		
	Sensitive	**Moderate**	**Tolerant**
Sandy, good drainage	Category 1 or 2	Category 1, 2, 3	Category 1, 2, 3, 4
Loam, good to moderately drained	Category 1 or 2	Category 1, 2, 3	Category 1, 2, 3, 4
Clay or poor drainage	Category 1	Category 1 or 2	Category 1, 2, 3

Soils with complex structures (including compacted layers) and stratified horizons will respond differently to water application and throughflow, so permeability of the root zone is another factor affecting use and efficacy of recycled water used for irrigation.

According to Grieve and others (2009), "It is not adequate only to identify maximum TDS or EC_w for use in landscapes containing salt-sensitive species; limits for sodium, chloride, boron, and RSC must also be established." Therefore, ranges for each of these components in each of the four water quality categories are identified in Table 2. These ranges were derived from a review of the literature listed in the references, as well as our experience over the last 20 years evaluating and analyzing soil, water, and tissue samples from landscape irrigated with recycled water.

Table 2: Interpretive guidelines for recycled water quality for landscape irrigation.

Species vary in tolerance to water quality. The poorer the water, the more severe are restrictions on use.

	Recycled water quality for landscape irrigation			
Parameter	**Category 1**	**Category 2**	**Category 3**	**Category 4**
Salinity				
TDS, mg/l	<450	450-640	640-1,000	>1,000
EC_w, dS/m	<0.7	0.7-1.0	1-1.5	>1.5
Specific ion toxicity				
Boron (mg/l)	<0.5	0.5-0.75	0.75-1.0	>1.0
Chloride (mg/l)	<100	100-180	180-300	>300
Sodium (mg/l)	<70	70-120	120-200	>200
Residual sodium carbonate (meq/l)	<1.25	1.25-2.5	>2.5	>2.5
Bicarbonate (mg/l)	<90	90-200	200-500	>500
Residual chlorine (mg/l)	<1	1-5	>5	

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NELDA MATHENY
CURRICULUM VITAE

HortScience, Inc.
2150 Rheem Dr., Suite A
Pleasanton CA 94588
(925) 484-0211

Summary of Qualifications

Ms. Matheny is founder and president of HortScience, Inc., a horticultural consulting firm. She specializes in tree evaluation and management, problem diagnosis and landscape suitability assessment. She has particular experience in tree preservation during land development and tree risk assessment and management. She is recognized for her extensive knowledge and experience in site evaluation, soils and recycled water use in landscapes.

Nelda has been instrumental in developing tree management programs for a variety of public agencies and private companies. She has developed methodology for tree risk assessments. She has provided training in tree risk management and preservation during development throughout the U.S., Great Britain, Italy, Canada and Australia.

Nelda is a Board Certified Master Arborist (WE-0195B) and a Registered Consulting Arborist (ASCA #243).

Certifications: Board Certified Master Arborist, #WE-0195B
Registered Consulting Arborist (ASCA #243)

Education: B.S. degree, Plant Science, Univ. of Calif., Davis, 1978
M.S. degree, Horticulture, Univ. of Calif. Davis, 1980

Experience: 1983 -- present, President, HortScience, Inc., a horticultural consulting firm providing problem diagnosis, tree preservation, landscape appraisals, and vegetation evaluation and monitoring, tree hazard assessment, landscape management programs.

1981 - 1983, Horticultural Consultant, Fruit Growers Laboratory, Inc., Santa Paula CA, a soil and plant tissue analysis lab.

1979 - 1981, Horticultural Consultant. Dean, Newman and Assoc., Westlake Village CA. Evaluated native trees and prepared tree preservation plans.

Professional activities:
Trustee, The Britton Fund, Western Chapter International Society of Arboriculture. 2006-present.
Member, I.S.A. Board Certified Master Arborist Committee, 2004-present; currently Chairperson.
Chair, Research Committee, Western Chapter I.S.A. 2002-2004.
Member, International Society of Arboriculture Research Trust, Board of Trustees. Vice Chair. Chair of Research Committee. 1992 - 1995.
Member California Urban Forestry Advisory Council, 1992 - 1993.

Member, Water Use Classification of Landscape Plants (WUCOLS). California Dept. of Water Resources. 1992-1993.

Honors and Awards:

Alex Shigo Award for Arboricultural Education. International Society of Arboriculture. 2007.
Award of Merit. Western Chapter International Society of Arboriculture. 2006.
Award of Merit. United Kingdom & Ireland Chapter, International Society of Arboriculture, 2005
Award of Merit. International Society of Arboriculture. 2000.
Author's Citation. International Society of Arboriculture. 1998.
Research Award. Western Chapter International Society of Arboriculture. 1993.
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***Publications*:**

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N. Matheny. 1990. Estimating landscape water requirements. Proc. 4th Annual N. California Xeriscape Conf.

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N. Matheny. 1989. Preserving trees affected by development. In: *A Technical Guide to Community and Urban Forestry in Washington, Oregon and California*. World Forestry Center, pp. 34-41.

AREAS OF EXPERTISE

- Soil Science and Soil Geomorphology
- Agricultural Capability Assessment
- Arboricultural Assessment
- Ecological Restoration
- Wetlands Assessment and Delineation
- Mining and Disturbed Land Reclamation
- Environmental Planning andCompliance
- Habitat Evaluation and Conservation
- Biological Resource Management
- Wetlands Mitigation and Monitoring
- Range and Watershed Management
- International Agricultural Development

EDUCATION

Ph.D. Candidate,
Plant Physiology/Soil Science
University of California, Davis

M.Sc., Botany
Texas Tech University, 1974

B. Sc., Zoology
Texas Tech University, 1970

RESEARCH SCIENTIST/LECTURER

Soil, Plant, and Water Science
University of California, Davis
University Extension
1974 - 2003

Botany, Zoology, Range Science
Texas Tech University
1969 - 1974

REGISTRATIONS/CERTIFICATIONS

Certified Professional Wetlands Scientist #748
Society of Wetlands Scientists

Professional Soil Scientist #123
Professional Soil Scientists Association of California

BIOGRAPHICAL STATEMENT

David B. Kelley is founder and president of Kelley & Associates Environmental Sciences, Inc., an earth, environmental, and agricultural sciences consulting firm and of Tuscan, Incorporated, a non-profit wildlands management organization. He has been a consultant on soils, land use, arboriculture, environmental resource issues, and rangeland and agricultural matters for over 25 years. He is a registered professional soil scientist, a certified professional wetlands scientist, and a consulting arborist and range scientist. Mr. Kelley has been directly responsible for numerous large-scale agricultural and environmental assessment projects as well as tree, rangeland, and wildland resource surveys and environmental constraints analyses. He has special interests in tree and soil relationships, wetland systems (especially vernal pools and riparian systems), soil science and geomorphology, agricultural assessment and development projects, land use issues and analyses, and environmental restoration. As a professional plant and soil scientist and arborist, Mr. Kelley performs specialized analyses of arboricultural issues, agricultural land assessments, wetland systems, range and timberland restoration, and vegetation management, and is a specialist in working with disturbed sites. He is a court-qualified expert witness and litigation consultant on soils, trees, and land use issues, and has had career-long involvement as a wetland scientist and consulting soil scientist/agronomist and agricultural land assessment expert for projects in North, Central, and South America (including Mexico, Belize, Guatemala, Venezuela, Ecuador, Peru, and much of the United States) and Southeast Asia (Hong Kong and the Philippines). He is often involved in litigation consultation, analyses, and testimony on tree and soil issues, land resource interpretations, wetlands and wetland soils, rangelands, and orchard and field crop problems.

Mr. Kelley's agricultural work has involved working with growers and the agricultural/rangeland industry throughout California, especially in the Central Valley, the Salinas Valley, and the central and southern coastal zones. Other clients have included environmental, water, and land-use attorneys; city, state, and federal governments and agencies; developers and environmental groups; miners, farmers, and ranchers; and engineers, appraisers, and design professionals. He has developed and teaches training courses for private- and public-sector agriculture and biology professionals and has prepared several books and publications for those classes

In addition to designing and implementing several large-scale environmental restoration projects in urban and agricultural settings, Mr. Kelley is a specialist in the relationships of trees and soils; soil science and soil geomorphology; and in most aspects of wetland delineations, agricultural development projects, and regulatory permitting. He has permitted many mitigation projects designed to compensate for impacts to wetlands and other natural resources and has been directly responsible for numerous resource surveys and environmental constraints analyses. Among other projects, his firm has created a large off-site vernal pool wetlands mitigation preserve in Butte County, encompassing natural and created vernal pools and plantings of an endangered species of vernal pool plant; designed, permitted, and developed as a mitigation project a 254-acre preserve in Yolo County incorporating a large oxbow lake built as mitigation for loss of riparian habitat on the Sacramento River; designed restoration/reclamation plans for several sand and gravel mines in northern California; designed a native plant community/endangered species habitat restoration effort for a marina and roadway project in southern California; and performed resource surveys and mitigation planning for projects ranging in size from 2 to 12,700 acres throughout California.

He is an officer in several professional organizations and participates in short courses and meetings of those groups. Many of his projects have involved working closely with professional colleagues with complementary talents, or finding appropriate resource professionals to undertake complex jobs requiring teamwork and multi-disciplinary approaches.

REPRESENTATIVE EXPERIENCE

Wetlands Assessment & Delineation

- **Carriage Park Development Project, Ashington Corporation, San Jose, CA.** Wetlands delineation, soil resource assessment, and mitigation design for 200+ acre residential development in Chico, California.
- **M&T Ranch Gravel Mine, Knife River Corporation, Bismarck, ND.** Environmental assessment and reclamation planning for 300-acre mining project.
- **Wetland Assessments—Washington, Oregon, Nevada, Texas, Montana, Hawaii, and other states.**
- **Wetland Assessments--San Diego, Orange, Los Angeles, San Luis Obispo, Monterey, San Benito, Santa Clara, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte, and other Coastal California Counties.** Coastal California wetland delineations and permitting for many clients.
- **Wetland Assessments—Sacramento, Yolo, Butte, Placer, Solano, Napa, San Joaquin, Merced, Madera, Fresno, Kern, and other Central Valley Counties.** Wetland delineations and permitting for many clients of the Central Valley.

Natural Resources Planning/Resource Assessments

- **Pebble Beach Golf Course and Residential Development, Pebble Beach Company.** Soil, biological, and wetland resource assessment.
- **Cameron Park Pipeline Restoration, Beak, Inc./M. Green.** Restoration design and resource assessment.
- **Butte County Mitigation Bank Restoration, CNLM/M. Green.** Department of Fish and Game streamside riparian restoration project.
- **Morrison Creek Restoration, Sacramento Concrete/Dowd.** Riparian resource survey and restoration planning for mitigation.
- **Putah Creek Vegetation Surveys, HortScience, Inc./Matheny.** Resource surveys and habitat design.
- **Lighthouse Point, Santa Cruz, Restoration Design, Backhaus Landscape Architects.** Resource assessment and design for natural areas.

Agricultural Projects

- **Gilroy Land Conversion Project, EMC Planning Group, Inc.** Soils capability/agricultural viability assessment for MVW Properties, Gilroy, California.
- **San Benito County Agricultural Land Assessment, Piini Ranch.** Land capability assessment.
- **Salinas Land Capability Assessment, Rush, Marcroft Associates.** Land capability assessment.
- **Carneros District Vineyard Soil Salinity Problems, B. Ward.** Soil and site assessment.
- **Ica, Peru Asparagus Production, Couture Farms.** Agricultural development and land use management of 2500+ acres in Ica, Peru.
- **Northern Salinas Valley, Soil and Water Assessment, T&A, Inc.** Assessment of soil and water resources and irrigation supplies.

Biological Assessment/Mitigation

- **Butte County/Highway 49, Caltrans.** Butte County Meadowfoam survey
- **Scotts Valley/Glenwood Development Project, Ashington Corporation.** Biological survey and wetlands assessment; Mitigation planning for a residential development and school in Scotts Valley, California.
- **Coalinga Asbestos Mine Reclamation, Southern Pacific Land Company.** Asbestos mine/mill site biological survey; reclamation/revegetation analysis, and wetlands delineation near Coalinga, California.

Soils/Site Assessment

- **Morgan Hill Recharge Facility, Santa Clara Valley Water District.** Soil assessment for Draft Supplemental Initial Study for spoil emplacement site at Morgan Hill Recharge Facility in Santa Clara County, California.
- **San Jose Soil Assessment, Santa Clara Valley Water District.** Soils and site assessment at mitigation planting site on Guadalupe River in Santa Clara County, California.
- **Guadalupe Gardens, San Jose, Soil Assessment, HortScience, Inc.** Soils assessment and investigation for Guadalupe Gardens in San Jose, CA., and for Hacienda Business Park in Pleasanton, California.
- **Petaluma Soil and Wetland Investigation, Zentner & Zentner.** Soils investigation along Thompson Creek for proposed Westridge subdivision, Petaluma, California.
- **Putah Creek Resource Assessment, Solano County Water Agency.** Vegetation and soil survey; riparian habitat assessment, and management plan development for Putah Creek, Yolo County, California

REPRESENTATIVE EXPERIENCE (Continued)

Restoration & Revegetation

- **Malibu, Los Angeles County Ranch Restoration, Cardoso Family Trust.** Horse ranch restoration, horticulture plan, and water quality protection plan.
- **Paradise Marsh Revegetation Project. Community Development Commission of the City of National City, San Diego County, CA.** Marsh and upland biological resource survey and habitat restoration.
- **Yolo County Habitat Restoration, Lighthouse Marina and Riverbend Development.** Soil resource inventory, riparian and wetland restoration and mitigation on 284 acres in Yolo County and West Sacramento (Kachituli Oxbow project).
- **San Benito County Revegetation Plan, County of San Benito.** Revegetation plan assessment for Granite Rock Mining Project at Brigantino, San Benito County, California.
- **Petaluma Riparian Restoration Assessment, City of Petaluma.** Review and analysis of revegetation plan for 100+ acre Thompson Creek Restoration/Riparian Enhancement Project.

Mining and Reclamation

- **M&T Aggregate Mining Project, Knife River Corporation, Bismarck, ND.** Gravel mining feasibility study on 300 acres in Chico, California.
- **Decker Island Resource Survey and Reclamation Planning, Mega Sand, Inc., Antioch, CA.** Geologic and soils survey; mining and revegetation plan and floristic survey of 658-acre disturbed area of Decker Island Mining Project, Sacramento River Deep Water Channel, California
- **Randsburg Soil Resource Survey, Rand Mining Company.** Soil resource inventory/assessment and determination of site revegetation possibilities for 532-acre Baltic Mine Project, Randsburg, California.

INTERNATIONAL PROJECTS

- **Hong Kong Soils and Wetland Assessment, Kowloon-Canton Railroad Company.** Wetland impacts litigation.
- **Mindanao, Philippines, Asparagus Losses Litigation, Rush, Marcroft, Inc.** Crop damages.
- **Belize Agricultural Development, DeVaney Land Company**. Crop and land development.
- **Dominican Republic Agricultural Development, IRI Research Institute**. Sugar diversification.
- **Ecuador Vegetable Crop Development, A. Hall**. Crop development.
- **Baja California Sur, Mexico, New Zealand Gourmet**. Crop assessment and land development.
- **Ica, Peru, Asparagus production, Couture Farms**. Agricultural development and crop export.
- **Trujillo Asparagus, Agency for International Development**. Agricultural assessment.
- **Tunisia Agricultural Development, H. Hoelscher**. Saline soil remediation and crop development.
- **Venezuela Asparagus Production, R. Percivale.** Agricultural development.

OTHER RELEVANT EXPERIENCE

EXPERT WITNESS. Court-qualified expert witness and litigation consultant with a career-long involvement as a soils expert, an arborist, a wetland scientist, and consulting soil scientist/agronomist and agricultural land assessment expert. Projects have included work in North, Central, and South America (including Mexico, Belize, Guatemala, Venezuela, Ecuador, Peru, and much of the United States) and Southeast Asia (Hong Kong and the Philippines). Testimony as an expert witness has included soil characteristics and origin, soil losses and stability, soil erosion, soil and plant issues involving tree failures, tree roots and infrastructure damage, wetlands and endangered species, agricultural damages and losses, soil capability and land resource management, and related subjects.

TEACHER. Frequent presentations to scientific societies and congresses on soils and land use assessment, wetland science and environmental restoration, mine reclamation, tree and orchard problems, range science, soil geomorphology, soil and water conservation, watershed management, and agricultural science. Numerous seminars for attorneys, insurance companies, developers, and public agencies on wetland delineation and permitting, environmental restoration, natural hazards, soil and water quality issues, toxic wastes, reclamation/revegetation of disturbed sites, erosion control, vegetation management, and conservation issues. Teacher and coordinator of professional plant and soil science short courses on natural and agricultural resource topics – soil science and geomorphology, ecological restoration, trees and soils, wetland science, expert witness and litigation consultation, agricultural soil and land capability, erosion control, agricultural development, environmental regulation, stream restoration, watershed management, and other subjects.

LANGUAGE PROFICIENCY

- English
- Spanish

PROFESSIONAL AFFILIATIONS

American Geophysical Union
American Quarternary Association
American Society of Agronomy
American Society of Consulting Arborists
Association of State Wetlands Managers
California Native Grasslands Association
California Native Plant Society
California Urban Forest Council
Friends of the Arboretum/University of California, Davis
Friends of the Biological Sciences Herbarium, California State University, Chico
Geological Society of America
International Erosion Control Association
International Society of Arboriculture
National Audubon Society
National Society of Consulting Soil Scientists
National Watershed Coalition
Northern California Botanists
Professional Soil Science Association of California
Society for Ecological Restoration
Society for Range Management
Society of Wetland Scientists
Soil and Water Conservation Society
Texas Tech University Student Association
The Wildlife Society
Tree Davis
University of California-Davis Alumni Association
Watershed Management Council
Western Society of Soil Science
Yuba Watershed Institute

SELECTED PUBLICATIONS

Kelley, D.B. 2000. **Tree roots and soils of the Davisville landscape: soil compaction, root distribution, and the soil landscape.** In: L.R. Costello, E.G. McPherson, D.W. Burger, and L.L. Dodge, eds. **Strategies to Reduce Infrastructure Damage by Tree Roots. A symposium for Researchers and Practitioners.** University of California, Davis, pp. 101-104.

Kelley, D.B. (In preparation) **Buffer zones for wetlands: habitat values, wetland protection, and technical complexity.** 6 pp.

Hobson, W.A., R.A. Dahlgren, and D.B. Kelley. (In preparation) **Aquic conditions and hydric soils along four vernal pool catenas, Northern California.** 27 pp.

Kelley, D.B. November 2000. **Soil and Water Quality Issues, Northern Salinas Valley, Monterey County, California.** Tanimura & Antle, Inc., Luhdorff and Scalmanini, Inc. and K&AES, Inc., Davis, California. 26 pp. plus exhibits.

Kelley, D.B. (ed.) 2000. **Strategies to Reduce Infrastructure Damage by Tree Roots. Field Trip Guidebook.** University of California, Davis. 22 pp.

Kelley, D.B. 2000. **Site evaluation and soils.** In: **Techniques and Strategies for Using Native Grasses and Graminoids in Restoration Projects. A CNGA Training Workshop Manual.** California Native Grass Association, Davis, California.

Kelley, D.B. 2000. **Reading the soil landscape.** In: D.B. Kelley (ed.) **Soils: Evaluation and Remediation. Caltrans Training Course Manual.** California Department of Transportation, Sacramento; University of California, Davis; and K&AES, Inc., Davis. Pp. 1-18.

Kelley, D.B. (ed.) 2000. **Soils: Evaluation and Remediation. Caltrans Training Course Manual.** Calif. Dept. of Transportation, Sacramento; University of California, Davis; and K&AES, Inc., Davis. 71 pp.

Kelley, D.B., R.C. Herriman, R.A. Dahlgren, and V.P. Claassen. 2000. **Assessment of Agricultural Soil II: Soils of Trees, Vines, and Other Perennials.** University Extension, University of California, Davis. 99 pp. plus exhibits.

Kelley, D.B., R.C. Herriman, R.A. Dahlgren. 1999. **Assessment of Agricultural Soils and Land Capabilities: The Basics.** University Extension, University of California, Davis. 158 pp.

Kelley, D.B., and R.C. Herriman. 1997. **Soil Geomorphology and Ecological Restoration.** Society for Ecological Restoration and K&AES, Inc., Davis, California. 185 pp.

Kelley, D.B. and R.C. Herriman. 1995. **Vernal Pool Wetlands and the Soil Landscape: An Introduction to Soil Geomorphology.** U.S. Fish and Wildlife Service, Sacramento, and K&AES, Inc., Davis, California. 78 pp. plus exhibits.

Kelley, D.B. and R.C. Herriman. 1994. **Wetland Soil Geomorphology.** Society of Wetland Scientists/K&AES, Inc., Davis, California. 171 pp.

Kelley, D.B. and G. Begg (eds.) 1989. **Field Identification of Hydric Soils.** Field Guide and Road Log. Professional Soil Scientists Association of California. 89 pp.

Kelley, D.B. 1984. **Halophytes as rangeland resources.** California Agriculture 38(10): 26-29.

Kelley, D.B. 1982. **Salt-affected rangelands: potential for productivity and management.** In: A. San Pietro (ed.) Biosaline **Research. A Look to the Future.** Plenum Publishing Corp., New York. Pp. 507-510.

Rush, D.W., D.B. Kelley, R. Richards, J.D. Norlyn, R.W. Kingsbury, and G.A. Cunningham. 1981. **Salt-tolerant crops. Solution to a complex problem.** Crops and Soils. October 1981:12-16.

Kelley, D.B., J.R. Goodin, and D.R. Miller. 1980. **Biology of *Atriplex*.** In: D.N. Sen and K.S. Rajpurohit (eds.) **Tasks for Vegetation Science. Vol. 2.** Dr. W. Junk, Publishers, The Hague, The Netherlands. Pp. 79-107.

Epstein, E., J.D. Norlyn, D.W. Rush, R.W. Kingsbury, D.B. Kelley, G.A. Cunningham, and A.F. Wrona. 1980. **Saline culture of crops: a genetic approach.** Science 210:399-404.

Kelley, D.B., J.D. Norlyn, and E. Epstein. 1979. **Salt tolerant crops and saline water: resources for arid lands.** In: J.R. Goodin and D.K. Northington, (eds.) **Arid Land Plant Resources.** Texas Tech University Press, Lubbock. Pp. 326-334.

Epstein, E., G.A. Cunningham, D.B. Kelley, R.W. Kingsbury, J.D. Norlyn, D.W. Rush, and A.F. Wrona. 1978. **Crop Production in Arid and Semi-Arid Regions Using Saline Water.** Univ. California, Davis. 151 pp.

Kelley, D.B. 1974. **Salinity Effects on Growth and Fine Structure of *Atriplex halimus* L.** M.S. Thesis. Texas Tech University, Lubbock. 70 pp.

CONTACT INFORMATION

DAVID B. KELLEY
CONSULTING PLANT AND SOIL SCIENTIST
PRESIDENT
K&AES, INC.
216 F STREET #51
DAVIS, CALIFORNIA 95616
TEL: 530-753-1232
FAX: 530-753-2935
E-MAIL: dbkelley@jps.net

DESIGNING LANDSCAPES USING RECYCLED WATER

by Nelda Matheny and James R. Clark

HortScience, Inc.
2150 Rheem Dr., Suite A
Pleasanton CA 84588
925 484 0211

Use of recycled water for landscape irrigation is increasing as supplies of potable water become limited. Recycled water can be an abundant source of inexpensive water or in some cases, the only source available for irrigation. Recycled water usually contains higher concentrations of some salts than potable (drinking) water. The maximum concentration of the salts is regulated by the state. However, those regulations are aimed at human and wildlife tolerances, not plant tolerances. Some plants are more sensitive to salts than animals and may be damaged when irrigated with water containing moderate to high salts.

Assessing recycled water quality

Water may contain ions or salts that are toxic to certain plants. While good quality water is suitable for use for irrigation of most any plant, poor quality water may inhibit plant growth or reduce health. For recycled water, the quality depends on the components of the water entering the treatment path, as well as the type of use before treatment. For instance, recycled water from municipal sources in which water softeners are used has a higher level of sodium than the water entering the system. During sewage treatment many of the inorganic compounds including salts and heavy metals are retained. Salts can be removed from recycled water through the process of reverse osmosis, although that is an advanced treatment that is not normally performed for water used in landscape irrigation.

The quality of a given recycled water source may vary through the year. In California, the quality of recycled water usually is better during the rainy season (winter) than during the periods of summer and fall drought. Water quality data may be requested from the treatment facility, or sample may be collected and analyzed by a laboratory. When requesting water quality data from the treatment facility ask for the range in measurements in addition to the annual averages normally reported. Water quality reports usually emphasize constituents of concern for human health. In some cases additional testing may need to be performed.

In the context of landscape irrigation, water quality refers to the presence and concentration of: total salts (TDS, Ec_w) as well as several specific ions (Cl, Na, B), bicarbonate, pH, trace elements and nutrients (N, P, K) (Table 1). Guidelines for interpreting water quality data are provided in Table 2.

[1] Adapted from Matheny, N., and J. R. Clark. 1998. Managing landscape using recycled water. In: *The Landscape Below Ground II*. D. Neely and G. Watson, ed. International Society of Arboriculture. Champaign IL.

Table 1: Constituents of recycled water that affect landscape plants and soils
(After Pettigrove and Asano 1985)

Constituent	Measured Parameter	Reason for Concern
Dissolved inorganics	Total dissolved solids (TDS); electrical conductivity (Ecw); specific elements (Na, Ca, Mg, Cl, B)	Excessive salinity may damage some plants. Specific ions such as chloride, sodium, boron are toxic to some plants. Sodium may pose soil permeability problems.
Hydrogen ion activity	pH	The pH of water affects metal solubility (e.g. Fe, Mn, Zn, Al) as well as alkalinity of soils.
Heavy metals	Specific elements (e.g. Cd, Zn, Ni, Hg)	Some heavy metals accumulated in the environment and are toxic to plants. Primary concern is for plants with high levels that are ingested by animals.
Nutrients	Nitrogen, phosphorus, potassium	N, P and K are essential nutrients for plant growth, and their presence normally enhances the value of water for irrigation. When discharged into the aquatic environment, N and P can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, N can lead to the pollution of groundwater.
Residual chlorine	Free and combined chlorine.	Excessive amounts of free available Cl (.0.05 mg/L Cl_2) may cause leaf-tip burn and damage sensitive plants. However, most chlorine in recycled water is in a combined form, which does not cause plant damage.
Suspended solids	Suspended solids	Excessive amounts of suspended solids cause plugging in irrigation systems.

Table 2: Interpretive guidelines for water quality for landscape irrigation. Species vary in tolerance to water quality. The poorer the water, the more severe are restrictions on species use. (After Pettygrove and Asano, 1985)

	Water quality for landscape irrigation		
Parameter	**Good**	**Fair**	**Poor**
Salinity			
TDS, mg/l	<450	450-2000	>2000
EC_w, dS/m or mmho/cm	<0.7	0.7-3.0	>3.0
Permeability[a]			
SAR	6	6-9	>9
Specific ion toxicity[b]			
Boron (B) (mg/l)	<0.5	0.5-1.0	>1.0
Chloride (Cl)			
Surface irrigation (mg/l)	<140	140-350	>350
Sprinkler irrigation (mg/l)	<100	>100	
Sodium			
Surface irrigation (SAR)	<3	3-9	>9
Sprinkler irrigation (mg/l)	<70	>70	
Miscellaneous effects			
Nitrogen (Total-N, mg/l)	<5	5-30	>30
Bicarbonate (HCO3)			
Sprinkler irrigation	<90	90-500	>500
pH		Normal range 6.5-8.4	
Residual chlorine			
Sprinkler irrigation (mg/l)	<1.0	1.0-5.0	>5.0

[a] Permeability affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together. At a given SAR, infiltration rate increases as salinity (EC_w) increases.
[b] Plant sensitivity to specific ions varies widely.

Total salts. Salinity is the most important measure of water quality for landscape plants. It is expressed as total dissolved solids (TDS) and electrical conductivity (EC_W). When water is applied to soils, some of the salts in the water (notably Na, Cl and B) remain in the soil. As these salts accumulate in the soil, plant toxicity may occur. Salt toxicity is first expressed as stunting of growth and yellowing of foliage. Burning of the edge of the leaves and defoliation usually follows. In severe cases, plants are killed. The degree of the problem depends on the sensitivity of the plant to salts and the concentration of the accumulated salts in the soil.

Specific ion toxicity. While salinity expresses the total salt content, it will not adequately identify potential toxicities from specific ions. Chloride (Cl), sodium (Na) and boron (B) concentrations in recycled water can and often do cause injury to sensitive plants. Boron in particular must be evaluated independently of other salts. It is toxic in such low concentrations (<1 ppm), that its presence will not be reflected in the general salinity measurement.

Sodium and chloride concentrations are particularly important if irrigation will be supplied by sprinkler. Plants will absorb both ions through their foliage. Toxicity through foliar absorption will occur at much lower concentrations than through soil absorption, particularly under high evapotranspiration conditions.

The toxicity symptoms of the specific ions are often difficult to distinguish from each other. Leaf chlorosis and marginal burning are typical. Necrosis associated with boron is often black in color and may appear as small spots near the leaf margin. As with salinity, plant tolerance to individual ions is highly species-specific. Some plants, like Indian hawthorn (*Raphiolepis indica*), can tolerate boron in excess of 7 ppm. Others like photinia (*Photinia* x *Fraseri*) are injured at 0.5 ppm. Furthermore, a plant may be relatively tolerant of boron, but highly sensitive to chloride. Little information is available to help develop lists of sensitivity of plants to specific ions. The landscape manager must rely primarily on experience and observation.

Sodium adsorption ratio. In addition to affecting plants directly, sodium can have negative effects on soil structure. It may cause dispersion of soil aggregates if present in high concentrations. This decreases both drainage and soil aeration which may cause plant decline and death. Soils high in clay are particularly susceptible to breakdown of aggregates by sodium.

Sodium hazard to soils is usually assessed from the sodium adsorption ratio (SAR), a value calculated from the sodium, calcium and magnesium concentrations. However, the permeability problems that can be caused by a high SAR can be partially offset by salts in the water. A more accurate measure of potential problems in irrigation water is the adjusted sodium adsorption ratio (adj R_{Na}) calculated from the salinity, bicarbonate, calcium, sodium and magnesium concentrations of the water.

Bicarbonate. Bicarbonate affects plants through its influence on pH and interaction with sodium. High bicarbonate can cause iron chlorosis symptoms in plants. Water high in bicarbonate, carbonate and calcium and/or magnesium can result in a white precipitate forming on foliage under sprinkler irrigation. Irrigation hardware is also susceptible to damage from bicarbonates. The precipitates can clog drip emitters.

When bicarbonate combines with calcium or magnesium in soils, calcium carbonate and magnesium carbonate precipitate out. Consequently the SAR of the soil increases, and permeability to water may become a problem. The bicarbonate hazard to soils can be evaluated by calculating the residual sodium carbonate (RSC). The RSC is the sum of the carbonate and bicarbonate ions minus the sum of calcium and magnesium ions. Water with an RSC>2.5 meq/l can develop permeability problems.

Heavy metals. Heavy metals are rarely present in water in sufficient quantities to be directly toxic to plants. However, most metals become tied up in the soil and their concentrations increase over time. Water quality criteria take the accumulation of the elements with many years of irrigation into account, and provide maximum concentrations with long-term use in mind. Effluent derived from domestic sources does not usually have problems with trace elements.

Nutrients. One of the advantages of using recycled water for landscape irrigation is that it contains plant nutrients and reduces the needs for application of fertilizer. Nitrogen (NH_4, NO_3), phosphorus (P_2O_5) and sulfur (SO_4) are the constituents of greatest benefit. Their concentrations are considered when evaluating recycled water to determine fertilization needs (Harivandi, 1988). Recycled water usually contains most of the micronutrients needed by plants. A negative aspect of this fertility involves storage of recycled water. Ponded nutrient-laden water develops algae and other aquatic weed problems more rapidly that potable water.

Designing and managing landscapes irrigated with recycled water

The potential problems to plants and soils can be minimized in a variety of ways, including both management and design. All of the management techniques require monitoring soil chemical and moisture characteristics, as well as plant responses. The main concerns are salinity and pH.. In addition, monitor water quality regularly because constituents can vary seasonally.

When designing new landscapes that will be irrigated with recycled water consider the following in the design:

1. Determine what the salt content of the recycled water will be. Check with the recycled water provider for a water analysis to determine concentrations of sodium, boron, and chloride. You may be able to access this information on the water agency's web site.

2. Avoid using salt-sensitive species. A list of species often damaged when irrigated with recycled water is provided in Table 3. If salt sensitive plantings cannot be avoided, irrigate on separate systems providing potable water.

3. Identify and solve drainage problems prior to planting. Good drainage is essential to using recycled water. Adjusting finish grades, eliminating hardpans and improving soil structure are methods to improve drainage.

4. Evaluate soil characteristics before planting. Soils should be tested for chemical and physical characteristics prior to planting to evaluate their suitability for irrigation with recycled water. Unfavorable conditions such as high sodium or chloride should be treated before planting to the extent possible.

When managing sites irrigated with recycled water, consider the following:

1. Minimize salt accumulation in the root zone. Minimizing salt accumulation is important to both avoid leaf burn and to avoid salt stress that can predispose plants to other problems. It is accomplished by leaching with heavy irrigations to flush accumulated salts below the roots. Annual rains may be adequate to maintain soil salinity within tolerable levels in some cases (heavy rainfall, well-drained soil). Where soils are heavier, leaching with good quality water may be needed during the growing season to lower salt levels.

Use of recycled water should be avoided in areas with poor drainage, since those areas cannot be leached.

2. Lower sodium concentrations in soils. If sodium concentrations become too high, drainage is impaired. Incorporating calcium (in the form of gypsum) into the soil and leaching can reclaim soil structure. Routine light applications of gypsum may be advantageous to avoid sodium problems.

3. Decrease fertilizer applications. Because recycled water contains significant amounts of nitrogen, phosphorus and potassium, applications of fertilizer can be reduced and in some instances, eliminated.

4. Increase irrigation frequency. Irrigation with recycled water should occur more frequently to dilute soil solutes, avoid water stress and minimize toxicity.

5. Moderate soil pH. Most plants tolerate a wide range in soil pH. As the pH of the soil begins to rise, however, acid-requiring plants may develop iron deficiency. Should chlorosis symptoms develop, the soil pH could be lowered by applying sulfur, or individual plants can be fertilized with iron to alleviate symptoms.

6. Monitor plant health. Additional stress factors caused by salts should be considered in the park's pest management program. Plant health must be monitored closely to identify stress-related problems that may develop. Some examples are bark beetles (*Ips*) on pines (*Pinus*), borers on alder (*Alnus*), and canker (*Seridium cardinale*) on cypress (*Cupressus macrocarpa*).

7. Monitor soil chemical changes. Soil conditions should be monitored through sampling programs to identify need leaching or other soil treatments. In most cases, soils should be sampled at the beginning and end of the irrigation period.

Recycled water can be an abundant, cost-effective source for irrigation. The landscape designers and managers should consider the quality of the water, soil chemical and physical conditions and sensitivity of landscape species to water constituents when planning and managing landscapes irrigated with recycled water.

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Table 3: Landscape species prone to damage when irrigated with water having moderate to high salt concentrations.

Scientific name	Common name
Acer japonica	Japanese maple
Alnus rhombifolia	White alder
Alnus cordata	Italian alder
Betula pendula	European white birch
Camelia jamponica	Camelia
Celtis sinensis	Chinese hackberry
Cinnamomun camphora	Camphor
Citrus spp.	Orange, lemon
Clivia miniata	Clivia
Clytostoma callistegioides	Violet trumpet vine
Cymbidium spp.	Orchid
Dicksonia antarctica	Tasmamian tree fern
Dietes iridioides	Fortnight lily
Eriobotrya japonica	Loquat
Escallonia x exoniensis 'Fradesii'	Escallonia
Eucalyptus ficifolia	Red-flowering gum
Eucalyptus nicolii	Peppermint gum
Eucalyptus sideroxylon	Red ironbark
Euryops pectinatus	Euryops
Fragaria chiloensis	False strawberry
Gardenia angusta	Gardenia
Geijera parviflora	Australian willow
Ginkgo biloba	Maidenhair tree
Howea fosteriana	Kentia palm
Hydrangea macrophylla	Hydrangea
Ilex cornuta 'Burfordii'	Burford holly
Lagerstroemia indica	Crape myrtle
Liquidambar styraciflua	Sweetgum
Liriope muscari	Big blue lily turf
Lophostemon conferta (Tristania)	Brisbane box
Magnolia grandiflora	Southern magnolia
Michelia champaca	Champaca
Morus alba	Mulberry
Musa spp.	Banana
Nandina domestica	Heavenly bamboo
Nephrolepis spp.	Sword fern
Philodendron	Philodendron
Phoenix robelenii	Pygmy date palm
Photinia fraseri	Photinia
Pinus thunbergii	Japanese black pine
Pinus torreyana	Torrey pine
Platanus x acerifolia	London plane
Podocarpus gracilior	Fern pine
Podocarpus henkelii	Long-leafed yellow wood
Podocarpus macrophyllus	Yew pine
Prunus cerasifera 'Atropururea'	Purple leafed plum
Prunus illicifolia lyonii	Catalina cherry
Quercus rubra	Red oak
Rhododendron sp.	Rhododendron
Rosa cultivars	Rose

Table 3: Landscape species prone to damage when irrigated with water having moderate to high salt concentrations, continued.

Scientific name	Common name
Sequoia sempervirens	Coast redwood
Sarcococca ruscifolia	Sweet box
Spathodea campanulata	African tulip tree
Sophora japonica	Japanese pagoda tree
Tabebuia sp.	Trumpet tree
Tibouchina urvilleana	Princess flower
Tilia cordata	Little-leaf linden
Viburnum tinus	Viburnum
Wisteria sinensis	Wisteria
Xylosma congestum	Xylosma
Zamia furfuracea	Cardboard palm
Zelkova serrata	Zelkova

IRRIGATION WITH RECYCLED WATER IN SANTA CLARA COUNTY: LIMITATIONS AND POTENTIALS

J.D. Oster, PhD

Emeritus Soil and Water Specialist
Department of Environmental Sciences
University of California, Riverside
5192 Kendall St.
Riverside, CA.
James.oster@ucr.edu
909 224 6785

1.0 INTRODUCTION

The Santa Clara Valley Water District (SCVWD) provided research funds to the University of California to assess appropriate treatment levels for recycled waters to be used for irrigation of landscapes throughout Santa Clara County. Studies were done at the University of California at Davis to determine the impact of water quality on Coastal Redwood and on soil hydraulic properties. The primary water quality parameters in these studies were electrical conductivity (EC) and sodium adsorption ratio (SAR[1]). The desired outcomes of the studies were to develop water quality recommendations and management plans related to irrigation of landscapes with recycled waters.

Coastal redwood is the primary plant species of concern. Observed leaf burn and tree death have been associated with irrigation with recycled water, indicating coastal redwood is very sensitive to salinity, sodium, chloride or a combination of all three. For the sustainable irrigation of trees and turf, adequate water infiltration and percolation rates through soil are essential to provide the water needed to maintain acceptable levels of electrical conductivity in the soil water (ECsw) and adequate soil aeration. If these rates are inadequate, the soil will become saturated, increasing runoff. If saturated conditions exist for several weeks, soil aeration will be limited, which can result in inadequate oxygen levels in the soil for trees.

This report uses the information obtained from these studies to recommend water quality requirements and the management practices that may result in healthy redwood trees in landscapes at Shoreline Golf Links in Mountain View, Villages Golf and Country Club in San Jose, and Wilson School in Santa Clara when irrigated with recycled water. To make these recommendations, I also used soil salinity and sodicity levels measured in August 2007 at these three locations.

[1] SAR = $C_{Na}/\sqrt{((C_{Ca} + C_{Mg})/2)}$ where C represents ion concentration in units of mmol(+)/L and the subscripts are the abbreviations for the chemical elements.

2.0 WATER QUALITY EFFECTS ON SOIL HYDRAULIC PROPERTIES.

Salinity and sodicity indices of water quality. Both salinity and sodicity affect the extent to which soil particles remain together or separate. When soil particles separate, the smaller soil particles can plug the large soil pores through which most of the water flows. This reduces the rate water can move into and through soils.

The higher the salinity of the irrigation water, or of the water in the soil, the more likely it is that soil particles remain together, and the less likely that soil particles will adsorb water and separate. Salts decrease the affinity of soil particles for water, and consequently their tendency to adsorb water and separate. In other words, the greater the salinity, the greater the stability of soil particles. The index for salinity is electrical conductivity of the irrigation water (ECiw), or of the soil water (ECsw).

The higher the sodicity, or sodium content of irrigation water, the higher the SAR of the soil water, SARsw, in the soil irrigated with that water, and the greater the likelihood soil particles will adsorb water and separate. The higher the SARsw, the higher the exchangeable sodium percentage (ESP) of the soil. As a general rule (U.S.D.A Handbook 60, 1954) for $0 < SARsw < 40$, $ESP \approx SAR$. With increasing exchangeable sodium, the affinity of soil particles for water increases and the stability of soil particles decreases. At a given SAR, the higher the ECiw, or ECsw, the greater the soil-particle stability.

Salinity and sodicity guidelines for irrigation water have been developed, and are used to assess the likelihood of adverse effects on water flow (Ayers and Westcot, 1985; Kearney Foundation of Soil Science, 1992). However, considerable judgment is required since no general guidelines apply to all soils (Pratt and Suarez, 1990). This is particularly true where rainfall can reduce the ECsw to near zero at or in close proximity to the soil surface (Oster and Schroer, 1979; Agassi et al., 1981; Quirk, 2001; Suarez et al., 2006).

In recognition of this situation, SCVWD funded the soils studies conducted by Beaudette and Singer (2007), who collected and worked with thirty soils in Santa Clara County. They found that the salinities of the percolating solutions had a larger impact on saturated hydraulic conductivities (Ksat) for a given soil than did the SAR of the percolating solutions.

Generally, Ksat decreased as salinity declined. Beaudette and Singer (2007) summarized the salt concentrations in the soil water at which a 15% reduction Ksat occurred as follows: “Seven of the thirty soils reached this threshold when the 100 mmol(+)/L solution was applied. Seven soils reached the threshold reduction in Ksat at 50 mmol(+)/L, five were affected with the 10 mmol(+)/L solution, eight were affected with the 5 mmol(+)/L solution, and three soils were not affected until deionized water was applied as the percolating solution." Division by 10 of the concentrations in this quote provides a good estimate of the ECsw. Consequently, the corresponding threshold values for ECsw are 10, 5, 1 and 0.5 dS/m.

In regard to the potential impacts of rain on its infiltration, the Ksat of all soils studied by Beaudette and Singer (2007) decreased considerably when the EC of the percolating solution was zero.

<u>Management of recycled water to maintain good rates of infiltration and percolation of water.</u> The EC and SAR of recycled waters are higher than Hetch Hetchy water (Table 1). Salts, particularly sodium salts, are higher for the Palo Alto Regional Water Quality Control Plant (PARWQCB) and South Bay Water Recycling (SBWR) waters than for Hetch Hetchy water (Table 1). Based on the EC of the waters in Table 1, the salt contained in an acre foot of water for Hetch Hetchy, PARWQCP, and South Bay waters is 0.2, 1.2, and 1.1 tons, respectively.

After several irrigations with a given water, the ECsw and SARsw of the surface soil become almost equal to the EC and SAR of the irrigation water. The EC of PARWQCB and SBWR recycled waters (Table 1) are lower than levels ($5 < ECsw < 10$ dS/m) at which Ksat of 14 of the 30 thirty soils declined more than 15 percent (Beaudette and Singer, 2007). Infiltration of rain will reduce ECsw to levels approaching zero within the upper inch or two of the soil. Thus, rain poses the possibility of further reductions in infiltration rates, as has been documented in several published papers (Oster and Schroer, 1979; Agassi et al., 1981; Quirk, 2001; Suarez et al., 2006). Also, as pointed out by Beaudette and Singer (2007), use of recycled waters with their higher SAR values will add sodium to the soil exchange complex. Although the major finding of their work was that ECsw had a greater influence on Ksat than SAR, where SAR had an effect, Ksat usually decreased with an increase in SAR. The prudent conclusion is that removal of the increased sodium will increase the stability of soil particles and the rate water infiltrates and percolates through soils.

Table 1. Water quality of Hetch Hetchy, Palo Alto Regional Water Quality Control Plant (PARWQCP) and South Bay Water Recycling (SBWR). Hetch Hetchy water is used at Shoreline Links, and SBWR is used at The Villages Golf and Country Club and at Wilson School.

Source of water	pH	EC	SAR	Ca	Mg	Na	K	Cl	HCO_3	SO_4	NO_3
		dS/m		mmolc/L (meq/L)							mg/L
Hetch Hetchy	8.9	0.2	0.78	0.75	0.52	0.62	0.03	0.34	0.95	0.4	nil
PARWQCP	6.6	1.35	5.31	2.30	2.80	8.48	UNK	9.25	1.56	1.01	18.7
SBWR	7.2	1.21	4.01	2.60	2.50	6.40	0.40	5.30	2.90	2.10	9.5

As pointed out by Beaudette and Singer (2007): “One option for managing the sodium and EC is to apply gypsum. Gypsum, along with sufficient leaching water, will help to remove sodium from the soil, and will maintain the EC so that soil structure is preserved.”

A particularly advantageous time of the year to apply gypsum is immediately before the rainy season. Infiltration of rainwater reduces ECsw near the soil surface to near zero. Application of gypsum at a rate of about two tons per acre in the fall before the rainy season begins will maintain ECsw at levels above zero near the soil surface, thereby reducing the effects of rain on infiltration rates. Gypsum in combination with infiltration of rain will remove sodium from the soil surface and leach it to deeper depths. Application of gypsum during the irrigation season will reduce SARsw, thereby decreasing the amount of sodium that needs to be removed. However, it will also increase ECsw. The salinity study conducted by Barnes et al. (2007) shows that an increase in ECsw by all the types of salt used in the study had an equal impact on salinity hazard to redwood trees.

The use of gypsum to mitigate effects of the higher SAR of recycled waters is recommended, but it needs to be used wisely. The amounts need to be limited, and timing needs to taken into consideration. The most critical time is before and during the rainy season, the coolest time of the year. This is the most favorable time to increase ECsw, because salinity effects on plant growth are less pronounced when the weather is cool and humid than when it is warm and dry (Maas and Grattan, 1999).

3.0 WATER QUALITY EFFECTS ON GROWTH OF GRASS AND TREES.

Generally, trees are considerably more sensitive to salinity than are grasses. For fescue and ryegrass, the threshold soil-water salinities, ECsw[2], at which growth is reduced range from 8 to 12 dS/m (Maas and Grattan, 1999). The threshold level for redwood is likely much lower based on the data reported by Barnes et al. (2007). They subjected redwood seedlings, *Sequoia sempervirens* 'Aptos Blue', to different salinity treatments for 16 months (Table 2). The water applied during that time exceeded the amount used by the trees for all salinity treatments by about 40 %. The excess (drainage) water was collected and its EC was measured (Table 2). The average EC of the applied water and drainage water, an estimate of the average ECsw in the rootzone, was 1.2 times the EC of the applied water (Table 2).

Table 2. Electrical conductivities (EC) of the applied water and drainage water for the salinity treatments in the studies conducted by Barnes et al. (2007). The average electrical conductivity of the soil water (ECsw) is the average of the EC of the applied and drainage waters.

Salinity Treatment	Applied water EC	Drainage water EC	Average ECsw
	dS/m		
Control	0.57	0.66	0.62
NaCl	1.05	1.67	1.36
NaCl	3.12	4.52	3.82
NaCl	4.32	5.71	5.02
NaCl	5.72	7.08	6.40
$CaCl_2$	1.06	1.54	1.30
$CaCl_2$	2.95	5.08	4.02
$CaCl_2$	4.52	7.1	5.81
$CaCl_2$	6.12	8.83	7.48
NaCl + $CaCl_2$	1.09	1.61	1.35
NaCl + $CaCl_2$	2.94	4.6	3.77
NaCl + $CaCl_2$	4.59	6.83	5.71
NaCl + $CaCl_2$	6.1	8.4	7.25
Na_2SO4	1.09	1.73	1.41
Na_2SO4	3.1	4.68	3.89
Na_2SO4	4.71	6.08	5.40
Na_2 SO4	6.1	7.37	6.74
Average	3.48	4.91	4.20
Average EC of drainage water/average EC of applied water = 4.91/3.48 = 1.41			

[2] The threshold salinities reported by Maas and Grattan are the electrical conductivity of saturated-paste extracts. I have multiplied them by 2.0 to convert them toECsw.

For all salinity treatments, little or no reduction in trunk diameter occurred when the EC of the applied water was 1.07 dS/m, the average EC of the lowest EC treatments. A reduction in trunk diameter together with moderate leaf burn occurred when the EC of the applied water was 3.03 dS/m, the average EC of the second lowest EC treatments. The corresponding ECsw values are 1.3 dS/m (no reduction in trunk growth) and 3.6 dS/m (reduction in trunk growth with moderate leaf burn). Redwood trees are much more sensitive to salinity than are fescue or ryegrass. Irrigation of redwoods that provides enough water to maintain acceptable values of average ECsw will be more than adequate for grass.

WATSUIT (Oster and Rhoades, 1990) was used to calculate the average ECsw in the rootzone as a function of leaching fraction for the three waters given in Table 1. WATSUIT assumes a 40:30:20:10 water uptake distribution, which is the same distribution used by Ayers and Westcot (1985). Two average ECsw values were calculated: the average ECsw for for the whole rootzone (Fig. 1), and the average ECsw for the upper half of the rootzone (Fig. 2). The ECsw values in both figures are much less than 8 dS/m throughout the range of leaching fractions. Consequently, irrigation of fescue and ryegrass with recycled water does not pose a salinity problem. Redwoods are another matter unless they are irrigated with Hetch Hetchy water. For the two recycled waters, the average ECsw for the whole rootzone (Fig. 1), and for the upper half of the rootzone (Fig. 2), is greater than 1.3 dS/m throughout the range of leaching fractions used to calculate ECsw.

Based on the findings reported by Barnes et al. (2007) for redwoods, an average ECsw greater than about 1.3 dS/m resulted in reduced trunk growth and an average ECsw of 3.6 dS/m resulted in leaf burn for all treatments. To prevent leaf burn, a major quality factor for ornamentals, the target average ECsw in the rootzone needs to be somewhere between 2 and 3 dS/m. For Palo Alto recycled water (Table 1), the most saline recycled water, the leaching fractions required to obtain these average ECsw values range from 0.25 to greater than 0.4 (Fig. 1). If redwood response to ECsw depends more on the average ECsw in the upper portion of the rootzone, than the average ECsw for the whole rootzone, then the corresponding target range of leaching fraction for Palo Alto water ranges from < 0.05 to 0.24 (Fig 2).

Letey and Feng (2007) proposed that plants are probably more responsive to the average ECsw in the upper portion of the rootzone (Fig. 2) than to the average ECsw for the whole rootzone (Fig.1). The salinities in Fig. 2 are considerably lower than those in Fig. 1. A leaching fraction of 0.23 for Palo Alto recycled water would result in an average ECsw of 2 dS/m in the upper portion of the rootzone (Fig. 2). Based on the growth in trunk diameter reported by Barnes et al. (2007), this level of ECsw may result in reduced growth. However, since the salinity treatments did not include one where the average ECsw was 2 dS/m, it is not known whether this average ECsw would cause leaf burn.

Whichever may be the best assumption about how redwoods respond to ECsw in the rootzone, in order to maintain ECsw at levels that do not cause significant damage to redwoods, considerably more water will need to be applied and infiltrated into the soil than what the trees require to meet their needs for evapotranspiration.

Use of recycled water poses a major salinity hazard to redwood trees. Leaching fractions greater than 0.20 to control soil salinity may be difficult or impossible to achieve for soils with low hydraulic conductivities, or for soils where infiltration rates are limiting. Other factors also are important: the need for very good irrigation management over the long run; and the variability of the salt tolerance among individual redwood trees; the erratic nature of rainfall in the area; and in rootzones with high water contents, anoxic conditions that can enhance the impact of soil salinity on leaf burn. Without a demonstrated ability to achieve the needed leaching fractions over the long run while maintaining acceptable levels of leaf burn, I cannot recommend the continual use of recycled waters with salinities greater than 1 dS/m to irrigate redwood trees .

Fig 1. Effect of leaching fraction on average salinity (ECsw) of the soil water in the rootzone calculated using WATSUIT

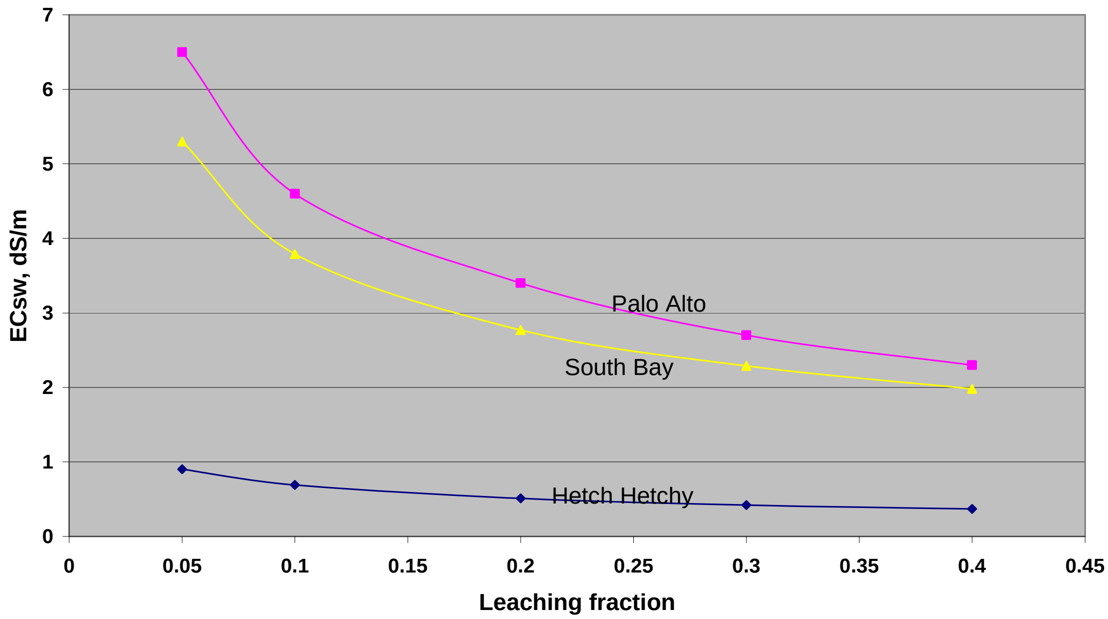
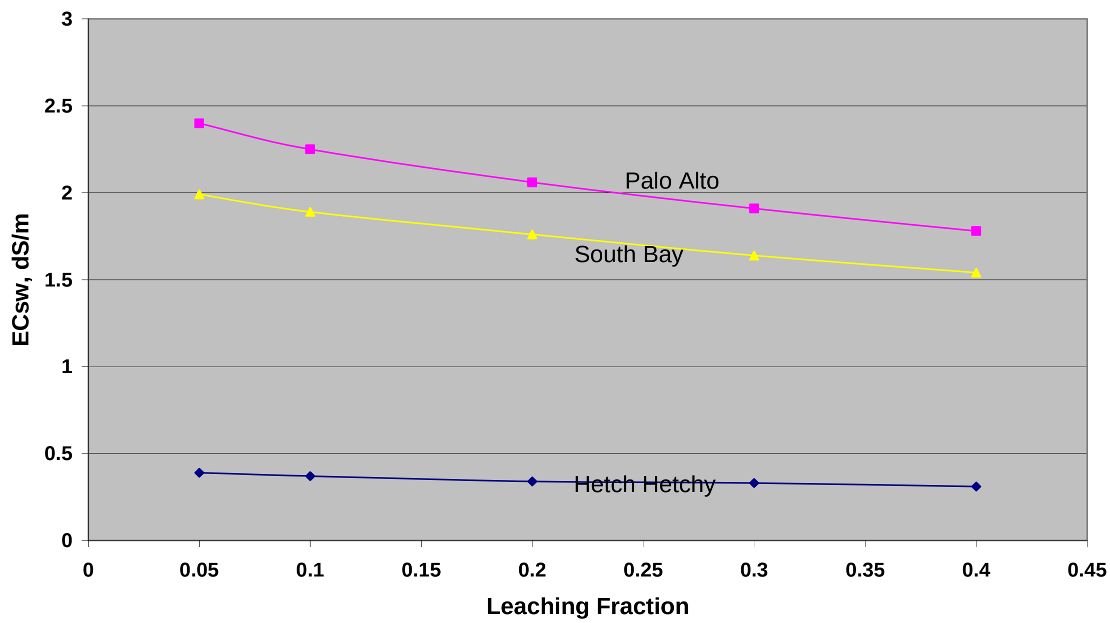


Fig. 2 Effect of leaching fraction on average salinity of the soil water (ECsw) in upper half of rootzone calculated using WATSUIT



4.0 WATER MANAGEMENT

Water requirements for turfgrass and trees can be estimated from reference evapotranspiration (ETo) calculated from measurements at weather stations located throughout California and provided by the California Irrigation Management Information System (CIMIS). The nearest CIMIS station is at Morgan Hill. Table 3 presents monthly values of ETo, which are the averages for the past 10 years. Absent the need to apply extra water to control ECsw by leaching, the water requirement (ETc) for closely clipped, cool season turfgrass equals 0.8 times ETo. The 0.8 is known as the crop coefficient. Where the irrigated landscape includes trees and grass, the crop coefficient for grass will not be affected unless there are several tiers of vegetation i.e. grass and closely planted shrubs, and some trees.

Rainfall is a significant factor that also needs to be accounted for when considering how much irrigation water to apply. The average rainfall during December, January and February exceeds the monthly ETc of closely clipped, well-watered, cool-season grass (Table 3). For the past 10 years, rainfall during December and January exceeded ETc in seven years. Rainfall exceeded ETc in February eight years out of ten. For six years, rainfall from December through February exceeded ETc by at least 7 inches. The rainfall for the individual years was 7, 8, 9, 10, 12 and 18 inches.

Seven inches of excess rain over ETc is sufficient to leach, or remove, about 80% of the salinity in the upper 14 inches of soil; 18 inches would remove about the same percentage in the upper 36 inches of soil (Hoffman, 1986). Consequently, the chance that rainfall will be sufficient to leach the upper 14 inches of soil is fairly high for any given year, and occasionally it will be sufficient to leach salts out of the upper 24 to 36 inches of soil. However, the chances of no leaching by rain are also significant. For December through February, subtracting ETc from rain for each of the other four years resulted in totals ranging from – 4 to 3 inches. Little leaching occurred during these years.

Finally, one needs to consider whether to use a rain-corrected salinity of the water applied during the summer. This is not necessary, since the amount of rain relative to ETc from May through October (Table 3) is about 7%. ETc from May through October totals 27.9 inches, or about 70 % of the total annual ETc. Most of the irrigation will occur during these months, and rain will not provide a significant reduction in ECsw.

Table 3. Average climatic data for the last 10 years at the Morgan Hill CIMIS station. ETo represents reference evapotranspiration of 4- to 7-inch tall cool season grass growing in an open field condition, and ETc represents evapotranspiration from closely-clipped, well-watered, cool-season grass assuming a crop coefficient of 0.8: ETc = 0.8*ETo (http://www.owue.water.ca.gov/docs/wucols00.pdf).

Month	ETo	Rain	ETc	Rain - ETc
	--------------- inch/mo ---------------			
Jan.	1.5	2.7	1.2	1.5
Feb.	1.8	4.3	1.5	2.8
Mar.	3.4	2.1	2.7	-0.6
Apr.	4.6	1.6	3.7	-2.1
May	6.1	0.7	4.9	-4.2
June	7.0	0.1	5.6	-5.5
July	7.0	0.2	5.6	-5.4
Aug.	6.0	0.1	4.8	-4.7
Sept.	5.0	0.1	4.0	-3.9
Oct.	3.7	0.5	3.0	-2.5
Nov.	1.9	0.9	1.5	-0.6
Dec.	1.4	3.3	1.2	2.1
Total	49.5	16.7	39.6	-23.1

Consideration of rain poses a confusing situation when considering how to irrigate redwoods. In general, irrigation needs to be based on ETo as measured on site, or at the Morgan Hill CIMIS station. There is a need to account for rain, particularly during December through February. Consideration of two situations, wet and dry rainy seasons, makes it a bit simpler. The following describes the differences in management of irrigation with recycled water for these two situations. It assumes a leaching fraction of 0.25 is needed to control ECsw, and that all the applied water will infiltrate into the soil.

5. IRRIGATION OPERATIONS

5.1 Wet years. Once two inches of rainfall have occurred in December, or in some years in November, stop regular irrigation with recycled water. Based on weather forecasts and the actual amount of rain at the site, avoid irrigation as much as possible through February. Doing so will minimize the salt applied to the soil, thereby optimizing a reduction in ECsw due to leaching by rain. After February, trees will benefit from the low ECsw in the upper portion of the rootzone. Underirrigation for a period of several months during late winter and early spring would be recommended to decrease the amount of salt added to the soil. However, during the summer, when there is little or no rainfall, the amount of infiltrated irrigation water (AW) needs to be about 1.33 times ETc to achieve a leaching fraction of 0.25 (Table 4).

5.2. Dry years. Applied water needs to be 1.33 times ETc throughout the year to achieve a leaching fraction of 0.25.

5.3. Discussion. The determination of how much water to apply is different for turf than for trees. The amount to apply to turf is based on the entire grassed area. For well-watered trees, the area from which trees obtain most of their water may be somewhat greater than the area shaded by a tree at noon. Multiplication of the shaded area by ETc and conversion to gallons per day yields the amount of water to apply to each tree. Assume a redwood shades a circle with a diameter of 20 feet. The area shaded is 314 ft^2. The daily ETc in June is 0.19 inch (Table 3). Multiplication of the area by 0.19 inch results in a volume of 4.9 ft^3, or 37 gallons, as the daily water requirement in June. If a leaching fraction of 0.25 is desired to control ECsw, then the total amount of water needed daily is 1.33 (Table 4) times 37 gallons, or 49 gallons. Finally, these numbers assume all the applied water infiltrates into the soil; that no runoff occurs.

Table 4: The relationship between leaching fraction and the ratio of applied water, AW, to annual crop evapotranspiration, ETc, and the amounts of AW required for three levels of ETc as a function of leaching fraction. The numbers for AW in the table assume all the applied water infiltrates into the soil and that all the area irrigated receives the same amount of applied water.

		ETc (inch)		
		30	*40*	*50*
Leaching fraction	*AW/ETc*	*AW (inch)*		
0.4	*1.67*	*50*	*67*	*84*
0.3	*1.43*	*43*	*57*	*72*
0.25	*1.33*	*40*	*53*	*66*
0.2	*1.25*	*38*	*50*	*62*
0.15	*1.18*	*35*	*47*	*59*
0.1	*1.11*	*33*	*44*	*56*
0.05	*1.05*	*32*	*42*	*52*

Because these calculations are -- at best -- only estimates, a back-up system based on soil measurements is recommended to assure that irrigation of redwoods is adequate. Several trees should be selected where the irrigation systems are fairly representative of all the irrigated trees. At these trees, a deep (3 ft) and a shallow tensiometer (1 ft), or other calibrated devices that measure soil water content, should be installed at two locations each about 7 feet from the trunk. The tensiometer readings at the 1 ft depth should be used to track the results of irrigation decisions made weekly. If irrigation is adequate, the readings will be less than about 20 kPa, or 20 cbar, several hours after irrigation. The tensiometer readings at the 3 ft depth would be used to track the results of irrigation decisions made monthly. They should be less than about 40. If they trend to values higher than 50, the amount of irrigation needs to be increased. If they trend to values lower than 30, the amount of irrigation could be decreased.

In addition, soil samples should be taken at the same depths and distances from the trees in March and September to determine the electrical conductivities of saturated-paste extracts (ECe). The ECe values need to be converted to ECsw by multiplying by two. Values of ECsw higher than 2.0 dS/m, particularly at a depth of 1 ft. in September, would indicate irrigation has not been adequate. Values in March at 1 ft would be expected to be lower than 2.0 dS/m if rainfall during the previous rainy season was sufficient to leach the soil. If so, then some underirrigation during April and May could be practiced, but with a close eye on the tensiometer readings at the 3 ft depth. They should be not be allowed to reach levels higher than 50. Upon reaching 50 kPa (cbar), full irrigation should begin. Finally, ECsw values in September should be less than 3 dS/m at both depths. If not, then too little water was applied during the summer.

6.0 FIELD OBSERVATIONS, AUGUST, 2007

Existing soil salinities and sodicities were determined on soil samples obtained in Aug. 2007 where recycled water was used or where its use was contemplated. This section deals with how these results compare to what was expected based on the quality of the applied water. It also further addresses how recycled water should be used to irrigate turf and redwood trees.

Soil samples were obtained in August 2007 at The Villages Golf and Country Club course in San Jose and at Wilson School in Santa Clara, where recycled water is used, and at Shoreline Golf Links in Mountain View where predominantly Hetch Hetchy water is used. Soil samples were taken on four fairways about 160 yards from the greens at locations midway between two or three sprinklers. Such a location should be representative of adequate irrigation due to overlapping water-application patterns from the sprinklers. A random number generator was used to select the four fairways. At Wilson School, the four sampling sites were in the irrigated turf about 25 feet from a line of redwood trees along the west side of the property. The first sample was about 195 feet from the south fence, and the distance between sampling sites varied from 100 to 150 feet. The soil was too dry beneath the tree canopies to sample.

Soil samples were obtained with a hand auger from five depth intervals: 2 – 5, 10 – 14, 22 - 26, 34 – 38, and 46 – 50 inches. They were double bagged in plastic zip-lock bags, labeled, and stored in a closed cooler. Field water content was determined at the SCVWD’s Rinconada Laboratory within 48 hours. The remaining samples were sent to Dellavalle Laboratory in Fresno for chemical analysis of saturated-paste extracts. Soil cores of the 2 – 5-inch layer were obtained with a double-cylinder, hammer-driven core sampler for the determination of bulk density and water retentivity at matric potentials of 0, -10, -20 and -40 kPa. These were done in Dr. Laosheng Wu's soil physics laboratories in the Dept. of Env. Sci. at the University of California, Riverside, and the results are in Table 5.

Table 5. Gravimetric water content in the 2 – 5-inch depth interval as a function of soil-water matric potential (ψ), as determined in the laboratories of Dr. L. Wu, at the University of California, Riverside.

Location with Fairway number (FN) for Shoreline and Villages and site number for Wilson School	Bulk density	Gravimetric water content			
		Ψ= 0.0 kPa	Ψ= -10 kPa	Ψ= -20 kPa	Ψ= -40 kPa
	Mg/m^3	%			
Shoreline FN 2	1.37	22.29	19.81	15.32	14.77
Shoreline FN 5	1.37	22.16	22.40	17.86	17.59
Shoreline FN 14	1.38	19.78	18.04	13.65	13.14
Shoreline FN 18	1.54	16.76	17.67	13.63	13.08
Villages FN 2	1.31	20.23	11.92	7.78	7.36
Villages FN 10	1.35	21.71	10.57	6.79	6.10
Villages FN 12	1.49	16.80	10.66	6.83	6.30
Villages FN 14	1.52	15.96	9.83	6.08	5.60
Wilson 1	1.34	21.45	17.74	12.87	12.30
Wilson 2	1.42	17.88	13.92	9.62	8.89
Wilson 3 [Data rejected]	~~0.87~~	~~54.23~~	~~34.42~~	~~29.56~~	~~28.60~~
Wilson 4	1.25	25.24	18.31	14.14	13.31

6.1 Shoreline Links. (Irrigated with Hetch Hetchy water, overlying a clay-capped and sealed land fill) The soil water content in the 2 – 5 inch depth (Table 6) corresponded to estimated soil-water matric potentials less than - 40 kPa at three of the four sites, based on the water retentivity data in Table 5. These low potentials indicate that insufficient water is being applied to meet the water needed by turf for ET plus that needed to control salinity. This finding is consistent with the high ECe, 12.7 dS/m, at the 2 – 5 inch depth, and the decrease in ECe with depth (Table 7).

Table 6. Field water content in the 2 – 5-inch depth interval and corresponding estimated soil-water matric potentials (ψ) for samples obtained on 13 August 2007. ψ was estimated from soil water retentivities (Table 5)

Location with Fairway number (FN) for Shoreline and Villages and site number for Wilson School	Field water content	ψ
	% dry wt.	kPa
Shoreline FN 2	13.0	ψ < -40
Shoreline FN 5	15.1	ψ < -40
Shoreline FN 14	16.9	-20 < ψ < -10?
Shoreline FN 18	11.7	ψ < -40
Villages FN 2	14.6	-10 < ψ < 0
Villages FN 10	14.6	-10 < ψ < 0
Villages FN 12	11.5	ψ ≤ 0
Villages FN 14	15.2	ψ ≤ 0
Wilson 1	12.1	ψ < -40
Wilson 2	12.6	-20 < ψ < -10
Wilson 3	13.3	ND
Wilson 4	18.8	ψ ≈ -10

The 12.7 dS/m in the 2 – 5 inch depth (Table 7), is unusually high considering the electrical conductivity of the Hetch Hetchy water, 0.20 dS/m (Table 1). The same is true for the chloride and sulfate concentrations: for chloride, 48.1 mmolc/L (Table 7) as compared to 0.34 mmolc/L (Table 1); and for sulfate, and 51.9 mmolc/L (Table 7) as compared to 0.40 mmolc/L (Table 1).

There was considerable variability in ECe (Appendix B) among the four sampling sites for the 2 – 5 inch depth. The individual values were: 2.3, 7.2, 17.5 and 23.9 dS/m. For the 46 - 50 inch depth the variability was smaller: the individual values were 6.1, 7.9, and 8.4 dS/m. Note that only three sites were sampled to a depth of 50 in. A rock precluded sampling deeper than about 26 inches at S2. The relative variabilities for the individual chemical elements were similar to the variability for ECe.

The decrease in ECe with depth is a normal distribution **if** a shallow water table is present. However, if a water table had been present at depths less than 50 inches, it would have been evident: the soil at the 46-50 inch depth would have

Table 7. Soil chemistry of saturated-paste extracts. Except as noted with an asterisk, values are averages of four samples; values with an asterisk are averages of three samples. Analyses run by Dellavalle Laboratory, Fresno CA. SP and FW represent saturated-paste and field water content; ECe represents electrical conductivity of the saturated-paste extract, and SAR represents sodium adsorption ratio.

location	Depth interval	SP	FW	pH	ECe	SAR	Cl	SO_4	NO_3
	inches	%			dS/m		mmolc/L		mg/L
Shoreline	2 - 5	51.3	14.2	7.8	12.7	8.5	48.1	51.9	17.1
	10 - 14	46.5	15.9	8.0	7.7	6.0	14.4	38.4	16.7
	22 – 26	44.0	24.3	7.9	6.4	6.4	13.6	25.1	11.7
	34 – 38 *	52.7	15.4	7.9	4.9	4.3	6.2	13.4	7.4
	46 – 50 *	48.7	25.8	7.8	7.5	4.5	8.2	19.0	72.8
Villages	2 - 5	33.8	14.0	7.4	4.4	5.6	12.6	17.1	3.8
	10 - 14	38.8	11.0	7.2	7.5	5.7	33.3	34.3	10.5
	22 – 26	27.3	11.2	7.4	4.3	5.5	16.5	23.2	9.2
	34 – 38	28.3	12.4	7.3	4.7	5.8	19.8	23.0	9.8
	46 - 50	29.0	13.0	7.3	3.9	8.4	16.1	19.0	4.6
Wilson	2 - 5	36.0	14.2	7.5	3.4	5.1	29.9	8.7	2.7
	10 - 14	45.3	8.6	7.5	5.1	6.6	45.0	9.3	27.2
	22 – 26	33.6	7.4	7.7	2.3	6.6	18.5	4.4	11.7
	34 – 38	33.3	7.1	7.7	1.7	3.9	11.2	3.9	8.3
	46 - 50	31.8	6.8	7.7	2.5	2.9	20.4	6.0	1.8

been very wet, and water would have begun to fill the lower portion of the sample hole. We did not encounter either. However, this does not preclude the possibility that there are times during the year, particularly during the rainy season, when the water table could be shallow. If so, then during the spring and summer the water table could drop because of slow downward percolation – mostly precluded because of a clay cap over the underlying landfill – and water use by the turf, trees and shrubs.

Another possibility is that ECe of 12.7 dS/m (Table 7) in the 2 – 5-inch depth is a consequence of underirrigation for several years with a consequent accumulation in the soil of the salts applied in the irrigation water. This would require the application of a large amount of irrigation water that has an EC of 0.20 dS/m. Based on the ECe of the 2 – 5-inch depth and the EC of Hetch Hetchy water, 0.2 dS/m (Table 1) it would take 25 cubic feet of water per square foot of soil, i.e. 25

feet of water, to apply the salt contained in this 3 inch depth interval. Assuming 2 feet of water are applied per year, it would take 12 years, to achieve the ECe measured in this small portion of the soil profile. Similar times were obtained using the chloride and sulfate concentrations (Tables 7).

> The following summarizes the calculations of the amount of salt, 0.097 lbs, in the 2-5 inch depth with an area of a square foot. 1. The ECe of 12.7 dS/m (Table 3) is converted to ppm using a factor of 640. The result is 8100 ppm. 2. A cubic foot of soil is assumed to have a mass of 93 lb (bulk density of 1.5 Mg/m^3). 3. At a soil water content of 51 % (=saturation percent, SP), there would be 12 lbs of water in a saturated paste made using all the soil in 2-5 inch depth with an area of a square foot. 4. Using a salt concentration of 8100 ppm, the amount of salt in the water is 0.097 lbs.
>
> The following summarizes the calculation of the mass of salt in a cubic foot of water. The EC of the Hetch Hetchy water, 0.2 dS/m, is converted to ppm using a factor of 640. The result is 128 ppm. 2. A cubic foot of water has a mass of 62 lb. 3. The mass of salt in a cubic foot of Hetch Hetchy water is 0.0038 lbs.

How representative were the four sites of the rest of the golf course? Based on the results of the EM survey of the entire course, conducted under the leadership of Dr. F. Cassel in April 2005, ECe's of less than or equal to 6 dS/m in the upper two feet of soil occurred in 30 – 50% of the areas in all fairways, with ECe's of greater than 6 dS/m in 5 – 15% of the area. Had the survey been done during August, the values would likely have been higher. The ECe values for the 2 – 5 inch depth obtained in August (Appendix B) at two of the locations are somewhat higher than expected based on the EM survey in April of 2005, but could not be considered to be excessively high.

It is reasonable to conclude the high salinities are not just the consequences of irrigation with Hetch Hetchy water. Other sources of salt that need to be considered include: irrigation with more saline water; the native salt in the soil, and upward movement of salt from deeper depths.

Whatever the explanation for the high ECe values, they must have occurred because the combination of existing water management and drainage precluded the ability to achieve some leaching. The average ECe values in the upper two feet of soil (Table 7) are sufficiently high to reduce the growth rate of moderately-tolerant, cool-season grass species such as fescues and ryegrass. The threshold ECe values for these grass species range from 4 to 6 dS/m (Maas and Grattan, 1999). Application and infiltration of more water than used by the turf on the fairways is urgently needed to reduce the soil salinity. However, doing so assumes the excess applied water will be able to move downward to depths below the rootzone. This may not be possible since the underlying clay layer seals and prevents downward movement of water into the land fill.

Since water management and drainage are limiting, any increase in the EC of the irrigation water will increase soil salinity. An increase in EC will require an increase in the amount of applied water that needs to infiltrate into the soil to maintain acceptable ECe levels. In turn, this will increase the soil water content and increase the amount of water that moves downward through the rootzone. This could be done with an irrigation system that does not apply water uniformly. However, the more nonuniform the application, the greater the amount of water required and the greater the need for subsurface drainage. However, the installation and maintenance of a drainage system that meets the needs for leaching and control of the water table depth could be difficult, considering that the underlying strata is a clay-capped landfill. Because of the hilly topography of the golf course, it is likely the depth to the clay layer is not uniform. The installation of additional drainage systems would need to take both the depth to the clay layer and the hilly topography into account to optimize the location of the drains. Drains need to be located below the water table in order to work. In addition, maintenance of the drainage system will need to contend with continual settling of the material in the landfill and overlying soil, which could result in breaks and blockage of the subsurface drain lines.

In summary: More irrigation water must be applied, and must infiltrate, than what is currently the case. A drainage system is required to remove the excess water needed to control soil salinity. Irrigation scheduling should adjust for climate so that more water is applied than used by turf. The amount of applied water should also be adjusted for irrigation uniformity, assuming it is not 100 % uniform. This should result in a large reduction in ECe in the upper foot of soil (Table 7), and gypsum may need to be applied to maintain infiltration rates, and to reduce areas in the fairways that become too wet.

Based on data reported by Beaudette and Singer (2007), the hydraulic conductivity of two of ten of the Shoreline soils decreased more than 15% when ECsw was less than about 5 dS/m (ECe of 2.5 dS/m), and for another two, a 15 % decrease occurred at an ECsw of 1 dS/m (ECe of 0.5 dS/m). Areas containing these soils will benefit from gypsum provided drainage is adequate.

Conclusion: Changing to PARWQCP recycled water, or a blend of recycled and Hetch Hetchy water, would be a mistake under existing conditions. Further, it is problematic that these conditions can be changed sufficiently to make the change possible in the future.

6.2 Villages Golf Course (Irrigated with South Bay recycled water). The soil water contents in the 2 – 5 inch depth (Table 6) correspond to estimated ψ values ranging from 0 to -10 kPa. A ψ of 0 would occur if the soil was saturated with water, and a somewhat lower water content occurs at a ψ of -10 kPa. These matric potentials indicate that sufficient irrigation water is being applied to provide the water needed by the grass. Based on the ECe and Cl concentrations of the 2 – 5 and 10 – 14-inch depths (Table 7), more water was applied than used by the grass. The excess water results in leaching, which controls the level of ECe in the rootzone. However the amount of excess water, or leaching fraction, is small.

6.2.1 Leaching fraction (LF). LF is the amount of water that moves downward, within and below the rootzone, divided by the amount of applied water. One can estimate LF by calculating ECsw and dividing it into the EC of the irrigation water (Table 1). The calculation involves two steps. The following shows the LF calculations for the 2 – 5 inch depth using the data given in Table 6.

1. First, ECsw is calculated:

ECsw = ECe(SP/FW) = 4.4(33.8/14) = 10.6 dS/m,

where SP is the water content of a saturated soil paste, and FW is the soil water content when the samples were obtained (Table 6).

2. Then the LF is calculated:

LF = ECiw/ECsw = 1.2/10.6 = 0.11.

> Where soil salinity within and below the rootzone of an irrigated soil does not change with time, the mass of salt added per unit of applied irrigation water must equal the mass of salt that leaves the rootzone in the drainage water. The mass of salt in a unit of water (V) equals the salt concentration [C] in the water times V. In other words, where soil salinity within the rootzone does not change with time, the mass of salt applied in the irrigation water, CiwViw, equals the mass of salt in the drainage water, CdwVdw, where the subscripts iw represents irrigation water and dw represents drainage water:
>
> *(Ciw)(Viw) = (Cdw)(Vdw),* *Eq.1*
>
> *or*
>
> *Vdw/Viw = Ciw/Cdw.* *Eq.2*
>
> *Leaching fraction (LF) is*
>
> *LF = Vdw/Viw...* *Eq. 3*
>
> *According to equation 2,*
>
> *LF = Vdw/Viw = Ciw/Cdw.* *Eq.4*
>
> *EC is proportional to C where the proportionality between EC and C is approximately independent of C. Consequenlty*
>
> *LF = ECiw/ECdw* *Eq.5*
>
> .
>
> *(Hoffman and Durnford, 1999).*

The chloride concentrations in the saturated-paste extract can also be used to calculate LF, following the same two-step calculation, where ECe is replaced by chloride concentration (Table 6). The result is a LF of 0.17. Since chemical reactions that involve dissolution of calcite affect ECe, but not chloride concentration, the LF obtained using chloride concentration likely is the best estimate.

The LF for the 10 – 14inch depth can be calculated with the same procedure. LF is 0.04 using ECe, and 0.05 using chloride concentration. This close agreement in LF, as compared to the results obtained from the 2 – 5 inch depth, results from the higher ECe in the 10 -14 inch depth, 7.7 dS/m, and consequently a lower relative error in calculating ECsw due to calcite dissolution.

A LF of 0.05 is lower than expected for the well watered situation at Villages. A higher leaching fraction could be expected for two reasons: 1. the soil water contents were high; the soil was wet enough for water to move downward in response to gravity, and 2. At the CIMIS station at Morgan Hill, the 10-year average rainfall between December 1 through February. 28 exceeds 0.8*ETo by a total of 6.4 inches (Table 2). 0.8*ETo is the estimate of evapotranspiration by turf. This would be sufficient to lower the ECe present on Dec. 1 by about 80 % (Hoffman, 1986) in the 0 – 14-inch depth at the end of February.

However, the rainfall that occurred between December 1 2006 and March 31, 2007 was 2 inches less than ETc for the same time period. Consequently, there was little or no leaching due to rain during the 12 months prior to Aug. 2007, when the soil samples were obtained. And the amount of salt in the 0 – 14 inch depth is consistent with that applied during one year of irrigation with SBWR water. Based on the average ECe of the 2 – 5- and 10 – 14inch depths, it would take about 3 feet of South Bay water to apply the salt contained in the 0 – 14 inch depth. This amount of water is somewhat less than the ETc for one year, 39.6 inch, or 3.3 ft (Table 2). Considering the small amount of rain during the preceding year before the soil samples were obtained, it is likely that more than 3.3 feet of SBWR water was applied.

The chloride concentrations for the depths below 10 – 14 inches also provide valuable information about leaching fractions. Downward movement of water due to leaching occurs slowly at depths below 2 feet. Consequently, the deeper one samples an irrigated soil, the further back in time one needs to consider when interpreting the results. Irrigation with South Bay water began in 2001 and continued until early 2004. Rainfall between Dec. 1 and Nov. 30 for the 2001-02 and 2002-03 seasons was 1.4 and 23.1 inches. Then use of South Bay water began again in July 2005 and continued without interruption until the end of July, 2007. The course was irrigated with potable water for August, September and October, 2007. Rainfall between Dec. 1 and Nov. 30 for the 2005-06 and 2006-07 seasons was 23.3 and 9.8 inches. The average rainfall during these years was 18 inches, or 1.5 feet. Because this amount of rainfall provides a significant portion of water to meet the needs of the crop, including leaching, one needs to use a rain-corrected average chloride concentration of the applied water. To make this calculation, the EC of rain is assumed to equal zero. Assuming that the total applied water is about 4.0 feet, of which 1.5 feet are rain, the rain-corrected chloride concentration of the applied water is about 3.3 mmolc/L. The chloride concentrations in the 20 – 24, 36 – 40, and 46 – 50-inch depths range from 16.1 to 19.8 mmolc/L (Table 7). Using the calculation procedure described above, the resulting leaching fractions range from 0.07 to 0.09, using 3.3 mmolc/L as the average chloride concentration in the applied water.

Conclusion: leaching fractions through and below the rootzone range from 0.05 to 0.10 under existing water management practices at Villages.

6.2.2 Leaching requirement. Is this range of leaching fractions adequate for moderately salt-tolerant turf grasses such as fescue or ryegrass, or redwood trees which are sensitive to salinity? The answers to these questions require consideration of changes in soil salinity that can occur during the year. Rain is usually sufficient in December through February to reduce the salinity in the upper foot of soil because rainfall exceeds ETc as is evident in Table 3. The soil salinity would then be expected to increase during March through about May, because the salt in the irrigation water is being added to the soil.

I chose to answer these questions based on the calculated steady-state salinities using the program WATSUIT (Oster and Rhoades, 1990). Doing so provides a worst-case scenario that I consider appropriate because steady state conditions in the upper foot or two of soil should be established by July. The consequences of adding gypsum were also taken into consideration, as were two leaching fractions, 0.1 and 0.3, and the possibility of blending South Bay water with potable water. To account for gypsum application, 13 mmolc/L were added to the Ca and SO4 concentrations in the SBWR water. This addition corresponds to an application of 6 tons/acre of gypsum dissolved in 4 acre feet of water. The average ECsw and SARsw for the whole rootzone and for the upper half of the rootzone are given in Table 8.

For leaching fractions of 0.10 and 0.30, the calculated ECsw values for South Bay (SB) recycled water (Table 8) pose no salinity hazard for turf. However, they pose serious salinity hazards for coastal redwood (Barnes et al., 2007) based on the average ECsw for the whole rootzone, and a potential hazard based on the average ECsw for the upper half of the rootzone. The existing leaching fractions at the time the soils were sampled were adequate for turf but not redwood trees.

Table 8. Soil-water electrical conductivity (ECsw) and sodium adsorption ratio (SARsw) for South Bay (SB) and a 50:50 blend of South Bay (SB) and Evergreen potable (EG) waters for two leaching fractions, with and without gypsum. Values for the average ECsw and SARsw are for two cases: whole rootzone and upper half of the rootzone. The impact of gypsum on the composition of the irrigation water was simulated by adding 13 mmolc/L to Ca and SO4 concentrations of the irrigation water. WATSUIT was used to calculate ECsw and SARsw.

A. Leaching fraction of 0.10

Water/amendment	ECsw, dS/m		SARsw	
	whole rootzone	upper half of rootzone	. whole rootzone	upper half of rootzone
SB	3.8	1.9	8.3	5.4
SB + 6 ton/acre gypsum	5.2	3.1	5.1	2.9
50:50; SB:EG	2.6	1.3	6.0	3.9
50:50; SB:EG + 6 ton/acre gypsum	4.1	2.6	3.5	1.9

B. Leaching fraction of 0.3

Water/amendment	ECsw, dS/m		SARsw	
	whole rootzone	upper half of Rootzone	Whole rootzone	upper half of Rootzone
SB	2.3	1.6	5.8	4.8
SB + 6 ton/acre gypsum	3.7	2.7	3.2	2.6
50:50; SB:EG	1.6	1.2	4.2	3.6
50:50; SB:EG + 6 ton/acre gypsum	3.0	2.3	2.2	1.8

6.2.2.1 Turf: In the fairways, leaching fractions through and below the rootzone range from 0.05 to 0.10 under existing water management practices at Villages.

For moderately salt-tolerant, cool-season turf grass, such as fescue and ryegrass, none of the ECsw values in Table 8 pose a hazard. For a salinity hazard to be considered possible, the threshold levels in ECsw would need to range from 8 to 12 dS/m. This assumes that the threshold salinities for these crops reported in ECe (Maas and Grattan, 1999) result in ECsw when multiplied by two. Consequently, a leaching fraction of 0.1 would be sufficient for South Bay recycled water. This conclusion applies also to the application of gypsum to maintain or improve the rate water infiltrates or flows through soil.

6.2.2.2 Redwood trees: The threshold ECsw above which growth would be reduced is about 1.2 dS/m (Barnes et al., 2007), with major reductions in growth and moderate leaf burn expected to occur at ECsw greater than 3.6 dS/m.

Based on the average ECsw for the whole rootzone (Table 8), where a 50:50 blend of South Bay and Evergreen waters, with an average EC of 0.8 dS/m, is used for irrigation, the targeted leaching fraction to prevent moderate leaf burn (EC < 3.6 dS/m) would be less than 0.10 without using gypsum amendment and somewhat less than 0.3 if gypsum amendment is used. If only South Bay water is used, than the target leaching fraction would need to be somewhat greater than 0.1 without using gypsum amendment and greater than 0.3 if gypsum is used.

If the average ECsw in the upper half of the rootzone better relates to the response of redwood to soil salinity, then these leaching fraction targets would be lower, with the highest targeted value being 0.10. However, this criterion for assessing targeted leaching requirements is still under study. It is included in this report to encourage future research to assess its validity, but it will not be used for making recommendations.

Water management on a golf course must deal with several constraints. Irrigation cannot occur when there are players on all the fairways. Playing on wet grass is not a preferred condition. Play cannot occur in areas where the soil is too wet to support the weight of golfers. There usually are areas where soil physical properties, such as low infiltration rates or low hydraulic conductivities, are limiting. They sometimes cannot be overcome by good irrigation and amendment practices. Consequently a recommendation to increase the amount of applied water at Villages to increase the leaching fraction in areas where redwood trees obtain water may not be possible to achieve with the existing irrigation system.

Conclusion. Blending recycled water with another source of water to reduce the EC of the applied water to 1.0 dS/m is recommended provided a targeted leaching fraction of at least 0.1 can be achieved during the summer in areas beneath the tree canopy. If only recycled water is used then the targeted leaching fraction needs to exceed 0.1, and could be as high as 0.3. Consequently the use of recycled water with an EC greater than 1.0 dS/m is not recommended.

6.2.3 Soil hydraulic conductivity, or soil permeability. Based on Beaudette and Singer (2007), the hydraulic conductivity of one of five of the Villages soil samples decreased more than 15% when the ECsw was less than about 5 dS/m; the same occurred for one soil at a salinity of 1 dS/m; two soils at a salinity of 0.5 dS/m, and one soil at a salinity of zero.

Consequently, reduction in hydraulic conductivities due to low ECsw is a possibility that requires consideration, and application of gypsum would be the recommended practice. Low ECsw during the rainy season poses the greatest likelihood of reduced rates of infiltration and water movement through soils (Oster and Schroer, 1979; Agassi et al., 1981; Quirk, 2001; Suarez, 2006).

If gypsum amendment is considered necessary, its use needs to be minimized because it increases the salinity hazard for redwood trees. All sources of salt were equally effective in causing leaf burn and in reducing growth of redwood. This was one of the major findings of the plant studies done at the University of California at Davis (UCD). Gypsum needs to be used sparingly, and attention needs to be paid to applying gypsum when it will be most effective. If gypsum amendment is necessary, a rate of about 2 tons per acre should be considered and it should be applied in late November or early December

6.3 Wilson School. The soil water contents in the 2 – 5-inch depth (Table 7) correspond to estimated ψ ranging from 0 to -40 kPa, which indicate that sufficient irrigation water may have been applied to provide the water needed by the turf. However, the water contents at depths below 10 inches are about one-half that in the 2 – 5-inch depth (Table 7). This decrease in water content with depth was not due to a remarkable change in soil texture with depth [see Appendix A]. Consequently, the higher water contents in the 2 – 5-inch depth likely resulted from a recent irrigation. The soil water content distribution with depth indicates that the turf is being underirrigated.

6.3.1. Leaching Fraction. The water, SBWR (Table 1), used at Wilson School has an ECiw of 1.2 dS/m with a chloride concentration of 5.3 mmolc/L. Using an ECiw of 1.2 dS/m and the method described in Section 6.2.1, the LF in the 2 – 5- and 10 – 14-inch depths ranged from 0.04 to 0.14. Using the chloride concentration, the corresponding range in LF was 0.04 to 0.07. At deeper depths LF ranged from 0.04 to 0.09 using rain-corrected ECiw (0.8 dS/m) and chloride concentration (3.5 mmolc/L). These low values for LF coupled with the low soil water contents below 10 inches (Table 7) indicate the grass at Wilson School is being underirrigated.

Underirrigation has some advantages in terms of salinity management. The less irrigation water applied, the slower the buildup of soil salinity. Also, the average salinity of the applied water, corrected for rain, is lower, since the relative contribution of rainfall to the total water applied increases as the amount of applied irrigation water decreases.

6.3.2 Turf: Since the grass is relatively tolerant of salinity and water stress, underirrigation doesn't pose a problem for using the grassed area for soccer, softball and etc.

6.3.3 Redwood trees: There doesn't appear to be any irrigation water applied beneath the canopy of the trees at Wilson School. Because it is very difficult to obtain soil samples with a hand auger in soils that are dry and hard, we were unable to sample beneath the trees. We sampled as close to the trees as possible.

All the ECe levels (Table 7) pose a hazard to Redwood trees, which is clearly evident when ECe is converted to ECsw. If irrigation water is not being applied beneath the tree canopy, the trees likely are also subjected to moderate water stress. The only source of water for the trees during the summer is the water applied to the grass. For this source to be significant, the lateral extension of the root system from the trunk would need to be more than 8 to 15 feet. It seems unlikely that the trees can survive the current situation, assuming application of South Bay water will continue to be used. If so, a separate irrigation system should be installed to irrigate the Redwood trees. That assumes it is essential that the trees survive at Wilson school.

A separate irrigation system is needed even if South Bay water is blended with potable water on a 50:50 basis. If the EC of the blended water is 0.9 dS/m, sufficient water needs to be applied during the summer to result in a LF of 0.10. A bubbler system (2 to 4 bubblers per tree) in combination with low border dikes to confine the water to 25 to 50 % of the area beneath the trees, would permit deep watering once or twice a week. Irrigation would need to start in about April and continue until more than two inches of rain occurs (~ Dec). During the irrigation season, the total amount of applied water per month should equal, or somewhat exceed, 1.1*ETo, calculated for an area equal to that covered by the canopy.

Blending potable water with South Bay water may not be legal considering the need to protect drinking water quality at the School. If potable ($EC_w \approx 0.6$) is the only alternative source of water to irrigate the trees, then the recommended LF would be 0.1 to maintain average rootzone ECsw levels at less than 3 dS/m. In this case, the separate irrigation system for the trees and water management practices described in the previous paragraph would still be recommended.

Consideration should be given to installing instruments to measure the soil water content to a depth of about 5 – 7 feet beneath the tree canopy. It is important to apply enough water to control both salinity and water stress without applying too much water. Too much water could result in poor soil aeration, and anoxic conditions for the roots. Anoxic conditions have been known to reduce the ability of some species of trees to tolerate salinity.

<u>Conclusion:</u> At Wilson School, the South Bay water can continue to be used to irrigate turf using existing water management techniques. However, if the coastal redwood trees along the property boundary are to survive, a separate irrigation system for the trees needs to be installed and the salinity of the applied water should not exceed about 1.0 dS/m. For the redwood irrigation system, blending recycled water with another source of water to reduce the EC of the applied water to 1.0 dS/m is recommended <u>provided</u> a targeted leaching fraction of at least 0.1 can be achieved during the summer in areas beneath the tree canopy. If only recycled water is used then the targeted leaching fraction needs to exceed

0.1, and could be as high as 0.3. Consequently the use of recycled water with an EC greater than 1.0 dS/m is not recommended.

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Appendix A. Field notes

Wilson School. Sampling date 8/13/2007; Erica and Bob

Sampled along S to N tree line

38 redwood trees along this line

Sample sites located along a line parallel to these trees, about 30 feet from the trees.

Grass was growing at all the sites.

Site 1 (W1); Between tree 7 and 8, 19 ft from tree line, 195 ft from S. Fence
Site 2 (W2): Between trees 14 – 16, off the end of the street W of the tree line, 27 feet from the tree line, 98 ft N of W1.
Site 3 (W3): Between trees 21 – 24, 21 ft from the tree line, 152 ft N of W2.
Site 4 (W4): Between trees 28 – 32, 29 ft from the tree line, 153 ft N of W3.

Leaf burn of the redwood trees along the S-N tree line may be related to distance from tree to lawn: with burn increasing as the distance increases. Tree line is not watered, or if it is, the amount of water applied is insufficient for grass to grow. The width of the bare area (tree line to where grass is growing) ranges from about 8 – 15 feet.

Soil texture:

Site number	0 – 6 inches	Below 2 ft
W1	Clay loam	Loam to Sandy Loam
W2	Sandy Clay Loam	Loam to Sandy Loam
W3	Sandy Clay Loam	Loam to Sandy Loam
W4	Sandy Clay Loam	Loam to Sandy Loam

Sampling depths:

Marked (inches)	Actual (inches)
2 - 5	2 – 5
10 - 14	10- 14
	22 – 26
	37 – 41
	50 – 52

Shoreline golf course: sampling date 8/13 (Fairways 2 and 5) in the evening (Erica and Bob) and 8/15 (Fairways 14 and 18) early morning (Bob).

Shoreline #2 (S2). Fairway 2; 150 foot marker at edge of poor area that was midway between two sprinklers. Center of fairway. Had to wait for two golfers to pass.

Shoreline #5 (S5) Fairway 5; 150 foot marker – side slope, left of center, midway between two sprinklers.

Shoreline #14 (S14) Fairway 14; 175 foot marker, left of center, midway between three sprinklers. Sampled early morning

Shoreline #18 (S18) Fairway 18; 175 foot marker, center, midway between three sprinklers.

Site number	0 – 6 inches	6 – 48 inches
S2	Clay loam	Clay, Clay Loam, Silty Clay Loam
S5	Loam	Couldn't sample below about 30 inches
S14	Loam	
S18	Sandy Clay Loam	Variable textures, including clay

Villages golf course: sampling date 8/14 (Fairways 2 and 10) between about 5 and 6 pm and (Erica), and (Fairways 12 and 14) between 6:30 and 8:15 (Erica and Bob). As with Shoreline, sampling locations were midway between two or three sprinklers.

Villages #2 (V2). Fairway 2; 225 foot marker west of center line about 30 feet East of marker. Had to wait for two lady golfers. Redwood tree with leaf burn along left side about 200 feet from white tees.

Villages #10 (V10). Fairway 10;175 foot marker right center between 2 sprinklers. Had to wait for two lady golfers.

Village #12 (V12) Fairway 12; 175 foot marker.

Village #12 (V12) Fairway 12; 175 foot marker, middle of fairway.

Site number	0 – 6 inches	6 – 48 inches
V2	Sandy Clay Loam to Loam (Rocky)	Same texture range as 0 – 6 inches and Rocky
V10	Loam	Same texture range as 0 – 6 inches and Rocky
V12	Sandy Clay Loam (rocky)	Same texture range as 0 – 6 inches and rocky, but not as much as V10
S14	Loam	Same texture range as 0 – 6 inches and rocky, but not as much as V10

Appendix B.
Dellavalle Lab. Data (Excel file)

Determining the Tolerance of Coast Redwood,

Sequoia sempervirens ‘Aptos Blue’

to Sodium and Chloride

Corey S. Barnes
Dr. Lorence R. Oki
Dr. Richard Y. Evans

University of California, Davis

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Introduction

Limited water resources in a state experiencing rapid population growth has stimulated the conservation of potable water and the use of recycled water for landscape irrigation in many locations throughout California (Wu *et al.*, 2000-2001). Sodium and chloride, two of the main constituents in the treated recycled water, have been suspected of causing the decline of redwood trees in the California South Bay Area where this water is used to irrigate public landscapes such as parks and golf courses. Symptoms noted on some redwoods irrigated with recycled water include leaf necrosis and in severe cases, branch and whole tree death.

South Bay Water Recycling serves the cities of Milpitas, Santa Clara and San Jose delivering an average of 15 million gallons of recycled water per day during the summer months (South Bay Water Recycling: About the System). The electrical conductivity (EC) of this water typically ranges from 1.0-1.5 dS/m (South Bay Water Recycling: Water Quality). In most years, sodium (Na) and chloride (Cl) are on average the ions in largest concentration in this water.

The objectives of this study are to determine the level of tolerance of Coast Redwood to these two ions by quantifying growth retardation, leaf ion accumulation and by recording the development of leaf burn symptoms in response to a set of salinity treatments composed of several salt concentrations and compositions.

Materials and Methods

Greenhouse Setup

Sequoia sempervirens ‘Aptos Blue’ saplings in #2 containers (~8 L) were arranged at 1 m alternate spacing in greenhouse 181 in the UC Davis Environmental

Horticulture Complex (Figures 1, 2). Trees were supplied by Van's Nursery in Modesto, California. Containers were approximately 21 cm tall and 21 cm in top diameter, tapering to approximately 18.5 cm at the base. *Sequoia sempervirens* 'Aptos Blue' has been reported as salt sensitive (Wu and Dodge, 2005) to a greater extent than the 'Los Altos' cultivar (Wu and Guo, 2006) and is a popular commercial variety (Wu and Guo, 2006). At the time this experiment was designed, *S. sempervirens* 'Aptos Blue' and 'Los Altos' appeared to be the only two cultivars previously studied with relation to salt sensitivity. Trees were divided into two blocks to control for gradients of sunlight, temperature and humidity across the house. Six trees replicated each of 16 salt treatments. Each block contained three randomly placed replicates for each treatment. The control treatment consisted of nine total trees; five in block 1 and four in block 2. Greenhouse day low and high temperature set points were 20.6 and 23.9 °C and night low and high temperature set points were 12.8 and 16.7 °C, respectively. No artificial lighting was supplied to the plants. The potting mix contained humus : sand in a 4 : 1 volumetric ratio, 6.0 kg/m^3 dolomite, 0.6 kg/m^3 calcium nitrate, 1.2 kg/m^3 ferrous sulfate heptahydrate, 3.0 kg/m^3 nitroform, 2.4 kg/m^3 treble super phosphate and 1.2 kg/m^3 oyster shell lime.

All treatments received a modified Hoagland's fertilizer "Solution 2" at an electrical conductivity (EC) of 0.5 dS/m (Table 1) (Hoagland and Arnon, 1950). This one-quarter strength Hoagland's solution served as the control irrigation treatment. Four salinity types were applied: sodium chloride (NaCl), calcium chloride ($CaCl_2$), an equimolar combination of sodium chloride and calcium chloride (NaCl + $CaCl_2$) and sodium sulfate (Na_2SO_4) (Table 2). Sodium chloride was included to test the effects of these two ions together, as they are the two constituents suspected of damaging coast redwood specimens in the field. Sodium sulfate was used to isolate sodium symptoms and calcium chloride served to isolate chloride symptoms. An equimolar combination of NaCl and $CaCl_2$ provided a treatment simulating environmental conditions, where more than one cation would be present in quantity in the irrigation water and/or soil (Oster, pers. comm.). Each salt type was added to the base Hoagland's solution to attain 16 treatments with conductivities of 1.0, 2.0, 3.0 and 4.0 dS/m. Treatments were initialized on 10/15/05. The dihydrate form of $CaCl_2$ and the anhydrous form of Na_2SO_4 were used for all treatments requiring these salts. Certified ACS-grade chemicals (meeting American Chemical Society purity standards) were selected for all ingredients except the iron chelate solution (Monterey Iron-All 5%, Monterey AgResources, Fresno, CA).

Three Netafim® Woodpecker pressure compensating emitters (Netafim Irrigation, Fresno, CA, rated 4 L/h) at each pot produced an average total flow rate of 12.8 L/h (standard error = 0.08, n = 9). Multiple emitters at each pot allowed for uniform saturation of the container medium, permitted daily irrigation of 17 stations in a timely period (± 1 h) and supplied sufficient flow rate for proper operation of the chemical injectors. Eighteen Dosatron® DI-16 injectors (Dosatron – North and Central America, Clearwater, FL) supplied the treatment solutions at the appropriate EC (Figure 3). The concentrated stock Hoagland's solution recipe was divided into two parts. Each part was mixed in a separate 8 L bottle and diluted by an independent injector. Potassium nitrate, calcium nitrate tetrahydrate and the iron chelate were mixed in the first bottle and ammonium phosphate monobasic, magnesium sulfate heptahydrate and all micronutrients were mixed in the second bottle. These solutions were divided in order to avoid precipitation problems with the high concentrations of the calcium, sulfate and phosphate-containing compounds used. On 12/5/05, the 2.0, 3.0 and 4.0 dS/m treatments were increased to 3.0, 4.5 and 6.0 dS/m, respectively, to hasten the progress of salt treatment effects. At this time, two concentrate bottles were used for each of the four salt treatment types. One bottle was used for the 1.0 and 3.0 dS/m treatments and the other was used for the 4.5 and 6.0 dS/m treatments (Figure 4). The Dosatron® DI-16 injector capabilities were limited such that two separate stock concentrations were required to deliver the range of target treatment concentrations.

Daily irrigations were scheduled with a Hunter® ICC irrigation timer (Hunter Industries Inc., San Marcos, CA). A leaching fraction of 0.4 to 0.5 was designed to be applied to all treatments independently. This fraction was employed to isolate symptoms related to the salt treatments by eliminating stress due to both insufficient water and increasing container EC due to evapotranspiration. Further, this leaching fraction was designed to provide sufficient irrigation treatment volume to allow for uniform saturation of the container medium.

Data Collection

Irrigation treatment solutions were evaluated on a weekly basis. One emitter tube at each tree was placed in a plastic bottle prior to the day's irrigation cycle to collect a sample of the treatment solution (Figure 5). After the irrigation cycle, a portable meter was used to test the EC of each sample and the solution was poured onto the potting medium surface. On the same day, leachate samples were collected. Tree pots were elevated on custom expanded metal stands (Dentoni's Welding Works, Inc., Stockton CA) and a plastic saucer was inserted below the stand, centered under the pot base

(Figure 5). After the treatment solution was poured onto the potting medium surface and the pot achieved container capacity (maximum water volume the potting medium could hold without further leaching from the container), a 45 mL sample was collected from each saucer and was analyzed in the laboratory for EC and pH.

Three growth parameters were regularly measured for each tree: trunk diameter, tree height and tree width. Trunk diameters were measured every second week starting on 9/25/05 and ending 1/3/07. A set of digital calipers (Fisher Scientific, Pittsburgh, PA) was placed around the trunk at a height of 3 cm above the potting medium in a constant orientation for each tree. The trunk was marked to indicate the points of contact for the calipers and the diameter was measured across these points each time. Tree height was evaluated every third week starting 9/15/05 and ending 1/8/07. Height was measured with a tape from an indicated point on the pot rim to the apex of the central leader of the tree (Figure 5). Tree width was determined every second week starting 11/16/05. Large articulating calipers were constructed to collect this data. These calipers were used to measure the distance between the western and easternmost lateral branch tips and the distance between the northern and southernmost lateral branch tips.

Five leaf tissue sampling events were scheduled at three to four month intervals during the experiment. Each sampling event was completed in two to five days. Dates of sampling completion were 10/17/05, 1/9/06, 5/18/06, 9/22/06 and 1/15/07. Shortly after the fifth sampling, the experiment was terminated. Consistency of tissue maturity was important in obtaining comparable results (Mills and Jones, Jr., 1991; West, J. R., pers. comm.). Therefore, only leaves produced during the previous flush of growth were selected for sampling. These leaves were identified as originating from lignifying stem segments occurring directly behind the youngest, light green leaves on solid green stems. Stem segments were further distinguished by noting their relative leaf length. If measured acropetally along the stem segment, the relative leaf length increased, reached a maximum and then decreased. Segments were selected around each tree, from the lowest branches to the tallest branches.

Both proximal (P) and distal (D) leaf blade sections were collected on each date. Leaf blades on the appropriate segments were transversely cut in half, first collecting the distal section (Figure 6). The halfway cut point was determined visually. As redwood leaves do not have discernible petioles, the proximal section was then removed by cutting the leaf from the stem as close to the stem as possible (Figure 6). Typically, both proximal and distal sections were collected from the same stem segments. A minimum of 1.47 g dry weight (3.75 g fresh weight, 39 % dry: fresh weight ratio) was collected for each sample. The day following sampling completion, samples were shipped via courier to Dellavalle® Laboratory, Inc. (Fresno, CA). Leaf samples were analyzed for ppm B, % Ca, % Cl, ppm Cu, ppm Fe, % K, % Mg, ppm Mn, % Na, % P and ppm Zn. This report will present the results for % Ca, % Cl and % Na. Calcium and Na were analyzed with the "Nitric / Perchloric Wet Ashing Open Vessel" (P – 3.10) technique and Cl was analyzed using the "2% Acetic Acid Extraction" (P – 4.20) technique of Gavlak *et al.*, 2003.

Digital photographs collected at each tissue sampling were used to track the symptom development of each plant. Pictures included a whole-plant image and close-up images of a specific primary branch, secondary branch and the apex of the central leader of each tree. A primary branch initially scored as healthy and free of damage was selected and tagged for photographic purposes. An image of this branch and one of the secondary branches attached to it were photographed on each picture collection date. This report will present the pertinent photographs taken on 1/10/07, prior to the final sampling event.

Results

Treatment solution EC varied slightly over the duration of the experiment. The greatest variant from the target EC was observed with the NaCl, 6.0 dS/m treatment, with a mean finalized EC (12/7/2005 to 1/9/2007) of 5.72 ± 0.08 dS/m (Table 3). Increasing treatment EC produced an increasingly greater leachate EC.

The increase in treatment EC from 2.0, 3.0 and 4.0 dS/m to 3.0, 4.5 and 6.0 dS/m, respectively, was apparent beginning on 12/5/05 (Figure 7). Variation in treatment EC occurred between 3/06 and 6/06, most notably for the three highest EC treatments within each salinity type. Treatment solution pH did not vary greatly by salinity type or concentration (Table 4).

Leachate EC for each treatment increased relative to the application EC (Figure 8). As treatment EC increased from 1.0 to 6.0 dS/m, the corresponding leachate EC differed by an increasing value. The control treatment leachate EC increased by approximately 20 % of the applied value. For each salt, the leachate EC from the 3.0 dS/m treatment was approximately twice as high as that from the 1.0 dS/m treatment. For the 4.5 and 6.0 dS/m $CaCl_2$ and NaCl + $CaCl_2$ salinity treatments, the leachate EC increased to approximately 8 and 10 dS/m, respectively. The 4.5 and 6.0 dS/m NaCl and Na_2SO_4 treatments produced leachate EC values of approximately 6.0 and 8.0 dS/m, respectively. Beginning in August of 2006 several saucers remained empty during a weekly leachate collection event, indicating that the designed leaching had not occurred (17 empty saucers in all from 8/06 to 1/07, less than 1 % of all samples collected during this period). The majority of these events occurred within the control and 1.0 dS/m salinity treatments and most events did not occur to the same replicate more than once.

Leachate pH values segregated by treatment as the experiment progressed (Figure 9). As treatment EC increased within a salinity type, the resulting leachate pH decreased. The NaCl and Na_2SO_4 salinity types yielded leachate values over a narrower pH range than the $CaCl_2$ and NaCl + $CaCl_2$ salinity types. All treatment leachate pH values were on average higher than the pH of the respective application solution (Table 4, Figure 9).

Mean relative trunk diameter values diverged by treatment until November 2006, most notably between the 1.0 dS/m treatment and the 3.0, 4.5 and 6.0 dS/m treatments (Figure 13). The relative trunk diameters of the 1.0 dS/m treatment of all salt types, with the exception of Na_2SO_4, closely followed those of the control treatment. The greatest change in relative trunk diameter for all treatments occurred during the period of April 2006 through November 2006, whereas the least change in relative trunk diameter occurred between December 2005 and February 2006. In general, as treatment EC increased within a salinity type, trunk diameter growth relative to 9/25/05 decreased. Five values, less than 0.2 % of all values, were removed from this dataset over the duration of the experiment due to measurement error. Specific replicates were not affected more than once. An analysis of variance (ANOVA) using the GLM procedure in SAS 9.1 (SAS Institute Inc., Cary, NC) on trunk diameter from 1/3/07 relative to 9/25/05 revealed a significant block and highly significant treatment effect at the 95 % confidence level (Table 5). On 1/3/07, the control trunk diameter relative to 9/25/05 was significantly greater than the 3.0, 4.5 and 6.0 dS/m treatments of all salinity types (Figure 11). Though not different from the control, the 1.0 dS/m NaCl and NaCl + $CaCl_2$ treatments were both different from the 3.0, 4.5 and 6.0 dS/m treatments within their respective salinity type. No differences were detected between any salinity treatments within the same EC level. Further, a significant difference was only detected in the Na_2SO_4 salt type between the 3.0, 4.5 and 6.0 dS/m treatments. Mean trunk diameter collected on 1/3/07 is presented in Appendix 1.

Increasing meq Na/L due to the four concentrations applied caused a decreasing trend in mean relative trunk diameter within a salinity type over the four concentrations applied (Figure 12). The $CaCl_2$ treatments displayed a decrease over the four treatment concentrations as well, although solution Na concentration in these treatments was zero. The NaCl + $CaCl_2$ treatments displayed a similar decrease in mean relative trunk diameter over the four concentrations, but the milliequivalents (meq) of Na/L were approximately 1/3 of the values of the other Na-containing salinity types at the same EC. The Hoagland's nutrient solution did not contain Na and, therefore, did not contribute this ion to any treatment (Table 1).

Increasing treatment meq Ca/L due to the treatments caused a similar decreasing trend in mean relative trunk diameter within a salinity type (Figure 13). The NaCl and Na_2SO_4 treatments displayed a decrease over the four treatment concentrations as well, although the meq Ca/L for these treatments was zero. The NaCl + $CaCl_2$ treatments displayed a similar decrease in mean relative trunk diameter over the four concentrations, but the meq Ca/L were approximately 2/3 of the values of the $CaCl_2$ salinity treatments at the same EC. The calcium contribution by the base nutrient solution was 1.70 meq/L (Table 1).

The influence on trunk diameter of both major cations combined (meq (Na + Ca)/L) is shown in Figure 14. The resulting slopes for mean relative trunk diameter for the four salinity types over the four meq concentrations of Na + Ca applied are very similar (-0.02) (Figure 15). The R^2 values for the control and four concentrations within each salinity type range from 0.72 for the $CaCl_2$ treatments to 0.81 for the Na_2SO_4 treatments. The Y-intercept values range from 2.69 for the Na_2SO_4 treatments to 2.80 for the NaCl + $CaCl_2$ treatments. Mean trunk diameter was similarly influenced by the total salinizing anions (Cl + SO_4) in one solution (Figure 16). Slopes and intercepts are clearly shown in the figures.

Mean relative tree height values and the corresponding standard errors overlap greatly (Figure 17). In general, as treatment EC increased within a salinity type, tree height relative to 9/15/05 decreased. Eight values were removed from this dataset over the duration of the experiment (less than 0.4 %) due to measuring inaccuracies. Some replicates were affected several times. Replicate 1-4 (control treatment) was permanently removed from height data collection beginning 1/26/06. Data points were removed for the NaCl + $CaCl_2$ 1.0 dS/m treatment from 7/10/06 to 9/14/06, for the $CaCl_2$ 1.0 dS/m treatment for 10/3/06 and for the Na_2SO_4 1.0 dS/m treatment for 8/24/06. An ANOVA using the GLM procedure in SAS on tree height from 1/8/07 relative to 9/15/05 produced a nonsignificant block and significant treatment result at the 95 % confidence level (Table 5). On 1/8/07, the control tree height relative to 9/15/05 was significantly greater than the 6.0 dS/m treatments of the NaCl and Na_2SO_4 salinity types (Figure 18). No statistical differences in relative tree height were detected within the $CaCl_2$ or NaCl + $CaCl_2$ irrigation treatments. Mean tree height collected on 1/8/07 is presented in Appendix 1.

Intermediate concentrations of meq (Na + Ca)/L caused the most variation in relative tree height (Figure 19). Without regard to salinity type, means of all 17 treatments showed a decrease in relative height over the range of meq (Na + Ca)/L concentrations. Regression of relative tree height calculated for each replicate on 1/8/07 compared to 9/15/05 yielded slopes ranging from -0.01 to -0.02 over the four salinity types and four concentrations imposed when graphed by treatment meq (Na + Ca)/L (Figure 20). The R^2 values for the control and four concentrations within each salinity type ranged from 0.19 for the NaCl + $CaCl_2$ treatments to 0.38 for the NaCl treatments. The Y-intercept values ranged from 2.22 for the NaCl + $CaCl_2$ treatments to 2.39 for the Na_2SO_4 treatments.

Tree width measurement activities were terminated in 4/2006 as this measurement proved to be too variable to obtain discernible results.

Over the five leaf tissue sampling dates, the control treatment demonstrated a slight decrease in % Na (Figure 22). The large standard error for the proximal value on 9/22/06 was caused by a single out-of-proportion value. There were no apparent differences in leaf section Na content on any sampling date. Four outliers were identified and removed from the % Na tissue analysis. These values represented less than 0.4 % of the total data analysis.

Leaf Na concentrations within the NaCl salinity type showed differences in accumulation over the five dates tested (Figure 23). On the second sampling date, 1/9/06, the leaf sections of the 1.0 dS/m treatment contained less Na than those receiving the three higher concentrations. The 1.0 dS/m treatment leaf % Na remained lower than the other NaCl treatments for the three final sampling dates as well. In addition, the Na content of leaves receiving the 3.0, 4.5 and 6.0 dS/m treatments diverged from the content of those exposed to the control treatment on 1/9/06, while the 1.0 dS/m treatment remained equal to the control values (Figures 22, 23). On 5/18/06, the NaCl 4.5 and 6.0 dS/m treatments diverged from NaCl 3.0 dS/m treatment. On 9/22/06, all treatments were distinguishable, with % Na leaf content increasing with increasing treatment EC. Few differences in Na content were apparent on 1/15/07 relative to 9/22/06. An unusually low proximal value in one replicate caused the % Na difference in the proximal and distal sections of the NaCl 3.0 dS/m section on 1/15/07. Few proximal and distal differences in leaf % Na were observed within a specific date and treatment. When differences were detected, the distal section content was greater than the content in the proximal section.

All $CaCl_2$ treatments demonstrated a decrease in leaf tissue % Na over the five sampling dates (Figure 24). The change became apparent on 5/18/06 and decreased to the minimum observed on 9/22/06. No difference was observed in % Na between 9/22/06 and 1/15/07. The leaf % Na in the $CaCl_2$ treatments was the same as that observed in the control treatment (Figures 22, 24).

The NaCl + $CaCl_2$ treatments displayed a lower level of Na leaf accumulation relative to the NaCl treatments over the experiment duration (Figures 23, 25). The Na leaf content resulting from the NaCl + $CaCl_2$ 1.0 dS/m treatment was comparable to that of the $CaCl_2$ treatments for the first three sampling dates, but maintained a higher concentration on the fourth and fifth dates (Figures 24, 25). Sodium leaf content in the NaCl + $CaCl_2$ 3.0, 4.5 and 6.0 dS/m treatments was not distinguishable when compared within each sampling date. These values were comparable to the % Na in the NaCl 1.0 dS/m treatment on each date (Figures 23, 26).

Sodium leaf content of the Na_2SO_4 1.0 and 3.0 dS/m treatments did not notably differ from the corresponding NaCl 1.0 and 3.0 dS/m treatments (Figures 23, 26). On the fourth sampling date, 9/22/06, a difference was observed in % Na between the NaCl and Na_2SO_4 4.5 and 6.0 dS/m treatments. These NaCl treatments acquired more Na by this date than the respective Na_2SO_4 treatment. Unlike the NaCl treatments, the Na_2SO_4 4.5 and 6.0 dS/m treatments continued to accumulate more Na between the fourth and fifth sampling dates. The leaf Na content of the highest three Na_2SO_4 concentrations were very similar within each sampling date. Mean leaf sodium content of all dates, treatments, sampling dates and sections are presented in Appendix 2.

Control treatment leaf % Cl did not change over the duration of the experiment (Figure 27). The relatively large error bar on the 1/15/07 proximal bar was caused by a single atypically large value. No differences were detected between Cl content of the proximal and distal sections. Eleven outlier values were identified and removed from the % Cl analysis. These values represented less than 1.1 % of the total data points in this analysis.

The NaCl treatment set did not begin to cause differences in % Cl leaf content until the third sampling date, 5/18/06 (Figure 28). The 1.0 dS/m treatment % Cl values did not differ until 9/22/06. Differences between the fourth and fifth dates were observed within the 4.5 dS/m proximal and distal section values and within the proximal 6.0 dS/m values. Several abnormally high values caused elevated means and SE bars in the NaCl set, specifically in the 4.5 dS/m proximal section on 1/15/07 and the 6.0 dS/m proximal and distal sections on 5/18/07.

Chloride leaf content in the $CaCl_2$ treatments did not cause a difference until 5/18/06 (Figure 29). With exception to the distal section on 1/15/07, % Cl in the 1.0 dS/m treatment did not change over the experiment duration. The top three concentrations could not be distinguished with relation to Cl accumulation. By 1/15/07, the leaf sections of the 3.0 and 6.0 dS/m $CaCl_2$ treatments had accumulated less Cl than the 3.0 and 6.0 dS/m NaCl treatments on the same date (Figures 28, 29).

The 1.0 dS/m NaCl + $CaCl_2$ treatment did not begin to differ in % Cl until 9/22/06 (Figure 30). The large proximal mean and error bar on the 1/15/07 NaCl + $CaCl_2$ 1.0 dS/m and 9/22/06 4.5 dS/m proximal treatments were caused by one atypically large value for each. The 6.0 dS/m treatment acquired more chloride than the other concentrations by 5/18/06. By the fifth date, this difference was not as apparent. Percent chloride did not change for any of the Na_2SO_4 treatments over the date sampled (Figure 31). These % Cl values were the same as the control treatment % Cl values.

Leaf calcium concentration in the control treatment did not vary over the experiment duration (Figure 32). Six outlier values were identified and removed from the % Ca analysis. These values represented less than 0.6 % of the total data points in this analysis. Mean leaf chloride content of all dates, treatments, sampling dates and sections are presented in Appendix 3.

The leaf Ca content due to the 1.0 dS/m NaCl treatment displayed results similar to the control values (Figure 33). Several proximal sections contained a greater amount of Ca than their corresponding distal sections. The NaCl 4.5 and 6.0 dS/m treatment % Ca values decreased on 9/22/06 relative to the other dates in these treatments.

Calcium leaf content in the $CaCl_2$ treatments increased steadily over the experiment duration (Figure 34). The 3.0, 4.5 and 6.0 dS/m $CaCl_2$ treatments caused similar increases in leaf Ca content. The 1.0 dS/m treatment demonstrated a lower level of Ca accumulation relative to the higher three concentrations beginning on 5/18/06.

The NaCl + $CaCl_2$ treatments did not cause leaves to accumulate Ca to the level of the $CaCl_2$ treatments (Figures 34, 35). The NaCl + $CaCl_2$ 3.0, 4.5 and 6.0 dS/m treatments were not distinguishable (Figure 35). The 1.0 dS/m treatment demonstrated lower leaf % Ca on dates 5/18/07, 9/22/07 and 1/15/07.

Calcium leaf content of trees exposed to the Na_2SO_4 treatments was also similar to the control values (Figure 36). However, the 9/22/06 dates demonstrated several values lower in Ca than the control and the other sampling dates for the Na_2SO_4 treatments. Mean leaf calcium content of all dates, treatments, sampling dates and sections are presented in Appendix 4.

On the final sampling date, 1/15/07, % Na for all four $CaCl_2$ treatments was equal to that of the control treatment (Figure 37). Leaf % Na demonstrated the largest differences between the control and the 1.0 and 3.0 dS/m level of any Na-containing treatments. The 3.0, 4.5 and 6.0 dS/m levels of any Na-containing treatments demonstrated the most similar values within each of those salinity types. However, the Na_2SO_4 3.0 dS/m leaf sections contained less Na than the 6.0 dS/m treatment on 1/15/07. Leaf sodium content of the NaCl + $CaCl_2$ treatments was less that the Na content of the other Na-containing treatments. Few proximal-distal differences were apparent.

The NaCl 6.0 dS/m treatment caused more Cl leaf accumulation than the 6.0 dS/m $CaCl_2$ treatment (Figure 38). The proximal section of the NaCl 6.0 dS/m treatment had a greater Cl content than either section of the NaCl + $CaCl_2$ 6.0 dS/m treatment. The other Cl-containing treatments were indistinguishable within EC level with exception to the proximal NaCl + $CaCl_2$ 4.5 dS/m section, which accumulated less Cl than the other salinity treatments of the same EC. Chloride content in the Na_2SO_4 treatments on 1/15/07 did not differ from the control treatment.

Within each concentration, the $CaCl_2$ treatments caused more leaf Ca accumulation than the NaCl + $CaCl_2$ treatments (Figure 39). No difference in Ca content was determined in leaves of the 4.5 dS/m and 6.0 dS/m treatments of any salinity type. The NaCl and Na_2SO_4 treatment leaf % Ca values were similar to the control values in content than to the Ca-containing salinity type treatments. Several leaf sections of the 3.0, 4.5 and 6.0 dS/m concentrations within these salinity types accumulated less Ca than the control.

Secondary branches of each control plant on 1/10/07 exhibited light tip burn symptoms (Figure 40). Tip burn developed on leaves of all ages and across all flushes of growth. Replicate 1-1 demonstrated necrotic spotting on the fresh leaves and stems. This symptom rarely occurred on the other replicates within the control treatment.

The NaCl 1.0 dS/m trees (Figure 41) displayed a level of leaf tip necrosis that was not distinguishable from the control (Figure 40) or other 1.0 dS/m trees (Figures 45, 49 and 53). This symptom was present across all flushes of growth. The dead branch segment in the bottom right of figure 41 did not originate from the replicate photographed. At the 3.0 dS/m concentration, a significant increase in leaf damage over the 1.0 dS/m and control trees was apparent (Figure 42). Necrosis began at the leaf tip and progressed in the basipetal direction. Damage was focused primarily on the most recent growth flushes and entire leaves and stem segments in this region were occasionally killed. Stem segments at the branch tips in the NaCl 4.5 dS/m treatment were regularly killed and the necrosis in this treatment affected a larger proportion of complete leaves from previous growth flushes (Figure 43). The images from the 6.0 dS/m NaCl treatment trees were not distinguishable from those of the 4.5 dS/m treatment (Figures 43, 44). The majority of replicate tree 5-3 was dead by 1/10/07.

Leaf tip necrosis on the $CaCl_2$ 1.0 dS/m treatment replicates (Figure 45) was not different from the control (Figure 40) or other 1.0 dS/m treatments (Figures 41, 49 and 53). Symptoms were regularly present on leaves of all ages. The 3.0 dS/m trees (Figure 42) demonstrated a similar level of necrosis to the 3.0 dS/m trees of the other salinity types except the NaCl + $CaCl_2$ 3.0 treatment (Figures 46, 54). Appearance of the $CaCl_2$ 4.5 dS/m and 6.0 dS/m trees (Figures 47, 48) were not different and were similar to the NaCl and NaCl + $CaCl_2$ trees of the same electrical conductivities (Figures 43, 44, 51 and 52). Frequently, necrosis on the 3.0, 4.5 and 6.0 dS/m $CaCl_2$ trees would exhibit a much redder color than the necrotic tissue on the 3.0, 4.5 and 6.0 dS/m trees not receiving $CaCl_2$.

Symptoms on the NaCl + $CaCl_2$ 1.0 dS/m treatment (Figure 49) replicates were similar to the control and other 1.0 dS/m treatments (Figures 40, 41, 45 and 53). The NaCl + $CaCl_2$ 3.0 dS/m trees demonstrated lighter symptoms than the other 3.0 dS/m treatment trees (Figures 42, 46, 50 and 54), but this treatment showed more leaf damage than seen in the NaCl + $CaCl_2$ 1.0 dS/m treatment (Figure 49). Fewer complete leaves and terminal stem sections showed damage at this concentration with the NaCl + $CaCl_2$ salinity type. Leaves and stem sections in the NaCl + $CaCl_2$ 4.5 and 6.0 dS/m treatments (Figures 51, 52) were not distinguishable in damage level from the NaCl and $CaCl_2$ trees at the same concentrations (Figures 43, 44, 47 and 48). The NaCl + $CaCl_2$ 3.0, 4.5 and 6.0 dS/m trees displayed the same reddish necrotic tissue as seen in the $CaCl_2$ treatments.

At the 1.0 dS/m concentration (Figure 53), the Na_2SO_4 salinity type did not visually affect the leaves and stems differently than the control and other 1.0 dS/m treatments (Figures 40, 41, 45 and 49). Similarly, the Na_2SO_4 3.0 dS/m treatment (Figure 54) was not different from the NaCl and $CaCl_2$ 3.0 dS/m salinity type treatments. The trees exposed to both the 4.5 and 6.0 dS/m Na_2SO_4 treatments exhibited heavier damage than trees irrigated with the other salinity treatment solutions at these electrical conductivities (Figures 55, 56). Many complete primary branches were dead by 1/10/07. Surviving secondary and tertiary branches were epinastic. One replicate in the 4.5 dS/m treatment and three in the 6.0 dS/m treatment were dead by 1/10/07.

Discussion

Treatment solution variation was caused by several factors. The decrease in treatment EC of the Na_2SO_4 solutions immediately after the initiation of the experiment was caused by precipitation of Na_2SO_4 in the concentrate stock bottles. As less Na_2SO_4 remained in solution, the stock concentration decreased leading to a decrease in the concentration of the treatment solution. This event was stimulated by both the high concentrations of these stock solutions and the decreasing night temperatures in the greenhouse. To remedy the issue, aquarium heaters were installed in Igloo coolers (Igloo Products, Inc., Katy, TX), the stock bottles were placed in the coolers and the coolers were filled with water. Water temperature in the coolers was controlled by the heaters and was maintained above the critical precipitation temperature, as determined by consulting a figure demonstrating the relationship between Na_2SO_4 solubility and temperature (Wikipedia: The Free Encyclopedia). Submersible pumps and flexible tubing provided heated water for the Dosatron® concentrate supply lines as well as for the base of the injector units to assure no precipitation occurred in these locations. Heated water lines, supply lines and the base of the injector units were wrapped with insulation. Between 3/06 and 6/06, all treatment solutions rose and fell in a similar pattern. The change in concentration increased as the treatment EC increased. The only common factor to all the injectors and treatments was the demineralized water supply line. Although a pressure regulator was installed upstream of the injector units, changes in supply pressure may have caused the EC variation observed. However, all treatments remained very distinct over the experiment duration, with few exceptions. The main factor affecting treatment pH was the 0.5 dS/m Hoagland's solution, which contained several acidic ingredients (Table 1).

Leachate EC tracked closely within a salinity type. Values rose and fell together over time. This was most likely due to changing evapotranspiration, influenced by both the changing greenhouse environment over the seasons and the growth of the trees.

Although the plants were greenhouse-grown, relative trunk diameter was affected by the seasons. The largest increases in relative diameter over time were observed between the months of April and November 2006 (Figure 10). The largest effects (decreases) in relative trunk diameter were observed between the 1.0 and 3.0 dS/m treatments for the NaCl, $CaCl_2$ and NaCl + $CaCl_2$ treatments. As EC increased, the effect on relative trunk diameter for these treatments decreased. When comparing the decrease between the 3.0 and 6.0 dS/m treatments, the differences in relative trunk diameter appeared similar. However, the difference between the 1.0 and 3.0 dS/m treatments is 2 dS/m, while the difference between the 3.0 and 6.0 dS/m treatments is 3 dS/m. The significant differences detected from the final trunk diameter collection date relative to the first collection date further emphasize the significance of the salt concentrations at the 1.0 dS/m level (Figure 11). From low to high EC, the first significant differences detected within a salt type between treatments other than the control occurred in all cases between the 1.0 dS/m treatments and either the 3.0 or the 4.5 dS/m treatments.

When relative trunk diameter was plotted against the meq of the major cationic constituents present in the salinity treatments, Na and Ca, the response was similar regardless of cation composition (Figure 14). Whether the major cationic constituent was sodium, calcium, or an equimolar combination of each, the resulting effect on relative trunk diameter was equivalent, as indicated by identical slopes and high R^2 values within all four salinity types (Figure 15). Relative trunk diameter plotted against the major anions present in the salinity treatments, Cl and SO_4, gave similar results (Figure 16).

Standard error for relative tree height was more variable than relative trunk diameter standard error. Several issues were encountered while collecting tree height measurements that contributed to this variability. At times, trees would push a competing leader (resulting in a secondary leader) that would be mistakenly measured. As trees increased in height, the apex became more difficult to measure accurately. Ladder use on an unleveled floor and flexibility of the central leader contributed to further variation in height measurement. In addition, this characteristic may have been inherently more variable than trunk diameter. Shading, greenhouse positioning and the sucker-producing tendency for many of the trees most certainly also contributed to the increased variability. Some suckers would grow 20 cm vertically in two months, while over the same period the proper shoot tip did not grow. This vigorous suckering differed by individual specimen and appeared to be independent of treatment or location. Mean values were removed on several dates due to incorrectly measured replicates. Typically, the one problematic replicate contributing to the treatment mean was one of the taller trees in the treatment. When this replicate value was removed, the mean appeared disproportionately low relative to mean values in the same treatment on surrounding dates. Due to this appearance and lack of relevance, the mean value was omitted from the graph.

Less seasonal change in relative height was apparent over time than the seasonal change with relative trunk diameter due to the increased variability in this dataset (Figures 9, 17). Relative height of the 1.0 dS/m treatments were not different from any other treatments (Figure 18).

Several trees grew tall enough to touch the greenhouse roof during the experiment. The greenhouse roof was sloped and the peak was oriented east-west and to the south of center across the two blocks. As trees encroached within 15 to 20 cm of the glass ceiling, they were exchanged with another tree in another location (Figure 21). Four parameters were imposed when selecting the exchange tree. First, the exchange tree must be shorter than the tree in close proximity to the ceiling. Second, the exchange tree must be positioned closer to the center of house (to allow more vertical space for growth). Third, the tree must be close to the same north-south positioning as the encroaching tree and within the same experimental block. Fourth, the tree meeting these parameters would ideally be a replicate of the same salinity type and EC as the encroaching tree. If a replicate meeting these four parameters could not be located, one meeting the first three was selected with no attention to salinity type or concentration. In this case, tubing and emitters were re-plumbed to deliver the appropriate treatments to both trees. In all, 17 trees attained a height that required relocation, resulting in 34 total trees moved.

Relative tree height was weakly correlated with the meq of the major cations in the salinity treatments, Na and Ca (Figures 19, 20). Slopes were very comparable, differing by only 0.01, but the low R^2 correlation in all cases made discussion regarding the concentration effects on relative tree height dubious.

Tree width variability was caused by both inter-tree competition for light and occasional suckering activity. As many lateral branches lengthened, they became pendant. Other vigorous lateral branches expressed a strong positive phototropic or negative gravitropic response, bending them upwards. These changing habits at times affected a lateral branch 10 – 20 cm basipetal from the tip, resulting in redirection of the shoot tip and a decrease in previously measured tree diameter. Vigorous lateral branches were also observed to change horizontal direction in response to shading by branches from surrounding trees. The articulating calipers constructed for measuring this parameter were accurate to ± 1 cm.

In response to the Na-containing treatments, the largest difference in leaf Na concentration occurred between the 1.0 dS/m and the 3.0 dS/m treatments. Accumulation rate increased as treatment concentration increased. The control and $CaCl_2$ treatments both demonstrated decreases in % Na over time due to the lack of this ion in these treatments. Proximal and distal sections were not different (Figures 22-26).

Increased air movement through several plants in block two was theorized to be the cause of the outlier values identified. The plants affected were in proximity to the two large cooling fans on the east wall of this block and it was theorized that an increased transpiration rate in these plants due to greater air movement contributed to the abnormally high ion concentrations observed. Outlier values were identified by studying the "Extreme Observations" output from the "proc normal" procedure in the corresponding statistical analysis in SAS. In order to qualify for exclusion from the analysis, the extreme observation must have met two qualifications. First, the value must have originated from a tree in proximity to the cooling fans. Second, only abnormally high results relative to the others from the same salt treatment qualified for removal. Abnormally low results, which occurred much less frequently, could not be explained with the theory described.

Leaf Cl accumulation was comparable to that of Na. The 1.0 dS/m concentrations of the Cl-containing treatments demonstrated an overall lower level of Cl accumulation relative to the three higher treatment concentrations (Figures 28-30), with exception of the proximal 1.0 dS/m NaCl + $CaCl_2$ treatment. Chloride accumulation increased as treatment concentration increased. However, differences between treatment concentrations were not apparent until the third sampling on 5/18/06. By the final sampling date, 1/15/07, most of these differences had disappeared. Leaf proximal and distal sections were not different (Figures 27-31).

Leaf Ca in the Ca-containing treatments also differed between the 1.0 dS/m and higher concentrations (Figures 34-36). All treatments contained Ca if only at base nutrient levels. No differences in leaf Ca were apparent until the third date, 5/18/06, when the 3.0, 4.5 and 6.0 dS/m treatments of the Ca salinity treatments diverged from the 1.0 dS/m treatment. Leaf proximal and distal sections were not different (Figures 32-36).

Differences in Na, Cl and Ca uptake due to the 1.0 and 3.0 dS/m treatments are shown in Figures 37-39. For all three ions, the largest difference in accumulation was observed between the 1.0 and 3.0 dS/m treatments for salinity types containing the ion for which they were tested (Figures 37-39). This observation was not as clear for % Cl in the 1.0 and 3.0 dS/m NaCl + $CaCl_2$ treatments. Further, the presence of Ca may have decreased Na uptake in the NaCl + $CaCl_2$ treatments. The concentrations of Na in the NaCl + $CaCl_2$ treatments were approximately 34 % of the meq Na in the NaCl treatments. However, % Na in the NaCl + $CaCl_2$ treatments was only approximately 25 % of the Na in the NaCl treatments (Figure 37).

Although several photographs were taken from each tree, the secondary branch images proved to be the highest quality and most descriptive. Secondary branch images of all salinity types clearly show the difference between the 1.0 and 3.0 dS/m treatments. The 3.0 dS/m concentration for all treatments was the lowest concentration where a visual distinction could be made with the symptoms of the control treatment. It is not understood why more trees died in the 6.0 dS/m Na_2SO_4 treatment than in the other treatments of the same EC.

A correlation may exist between leaf necrosis in the 4.5 and 6.0 dS/m treatments and the concentration and/or exposure time of the salinity types utilized. The majority of the leaves photographed on 1/10/07 and sampled on 1/15/07 in the 4.5 and 6.0 dS/m treatments were dead. In addition, within a salinity type and an ionic analysis on this date, % Na, % Cl and % Ca for these two treatments could rarely be distinguished

(Figures 37-39). On 1/15/07, the 3.0 dS/m treatments displayed more differences with the two higher treatments than they did between them and the 1.0 dS/m treatments were most all different from these two treatments. Most tissue results followed the same pattern, with decreasing damage as treatment concentration decreased to the 1.0 dS/m level. Given more exposure, it is not known whether the 1.0 and 3.0 dS/m concentrations may ultimately have achieved the same level of tissue content and damage as the 4.5 and 6.0 dS/m concentrations.

Conclusions

The response of *Sequoia sempervirens* 'Aptos Blue' to the salinity treatments in this study indicates a clear increase in detrimental effect with increasing treatment concentration. Although initially included as counter ions to isolate Na and Cl responses, both the Ca and SO_4-containing treatments had similar detrimental effects to the NaCl treatments. The NaCl + $CaCl_2$ treatments did not exhibit a reprieve over the NaCl treatments. Based on the equal slopes and R^2 values obtained in the total cationic concentration vs. relative trunk diameter data and the plant photographs collected on 1/10/07, the effects of the salinity treatments on the redwood trees were more related to total salinity rather than to specific ion effects. No distinction can be made between Na effects and Cl effects. The tissue analyses included are most useful in determining leaf tissue concentrations at which undesirable visual symptoms occur- whether they are decreased trunk diameter and height, or leaf necrosis and tree death. Although very few differences between proximal and distal sections were noted, if these results are used to compare with whole-leaf tissue results obtained elsewhere, the following equation can be used to convert the proximal and distal tissue results to a whole leaf value for a particular element:

Whole leaf mean = (Proximal leaf mean + Distal leaf mean) / 2

Both the trunk diameter analysis and visual leaf symptom monitoring demonstrated no differences between the control and 1.0 dS/m treatment levels. However, the 3.0 dS/m treatments are largely different from those two treatment levels. Thus, water that will maintain the soil solution at an EC close to 1.0 dS/m would appear to decrease the likelihood of producing detrimental symptoms on redwood trees irrigated with recycled water. Recycled water quality with relation to this chemical aspect does not appear to be the principal issue causing the redwood decline noted in the greater South Bay. Even at the relatively low conductivity of 1.0 dS/m, salt can accumulate in the soil profile if proper leaching is not employed to carry the salts out of the root zone. This study intentionally employed a high leaching fraction to minimize salt accumulation in the pots. It is clear that redwoods can tolerate EC values in the range typical for recycled waters if irrigation is properly managed.

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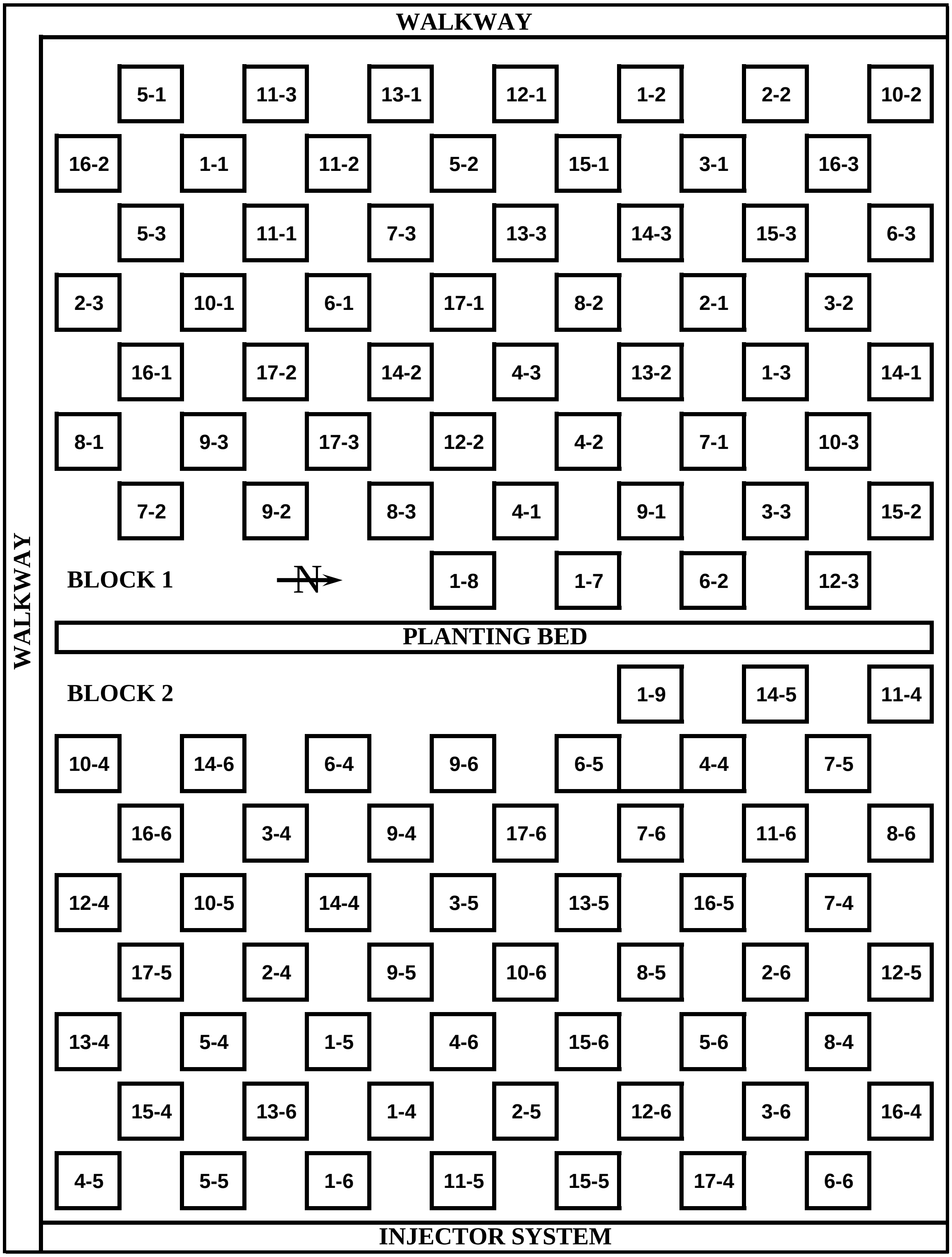

Figure 1. Greenhouse map. Numbered squares designate treatment-replicate identification and position for each tree.

Table 1. Treatment 1: Modified Hoagland's solution composition, 0.5 dS/m.

Component	g/L	meq/L Na	meq/L Cl	meq/L Ca
$NH_4H_2PO_4$	0.024			
KNO_3	0.13			
$Ca(NO_3)_2·4H_2O$	0.20			1.70
$MgSO_4·7H_2O$	0.10			
H_3BO_3	0.00061			
$MnCl_2·4H_2O$	0.00039		0.0039	
$ZnSO_4·7H_2O$	0.000047			
$CuSO_4·5H_2O$	0.000017			
$H_2MoO_4·H_2O$	0.0000043			
Iron chelates: ETDA, citric acid	0.00060			

Table 2. Treatments 2-17: Salinity treatment composition.

Trt. no.	Salinity type	EC (dS/m)*	Component	g/L	meq/L Na	meq/L Ca#	meq/L Cl#	meq/L SO_4#
2	NaCl	1.0	NaCl	0.25	4.38	1.70	4.39	0.85
3		3.0		1.33	22.91	1.70	22.92	0.85
4		4.5		2.19	37.71	1.70	37.71	0.85
5		6.0		3.05	52.56	1.70	52.57	0.85
6	$CaCl_2·2H_2O$	1.0	$CaCl_2·2H_2O$	0.33	0.00	6.28	4.58	0.85
7		3.0		1.70	0.00	24.95	23.26	0.85
8		4.5		2.87	0.00	40.91	39.21	0.85
9		6.0		3.97	0.00	56.03	54.33	0.85
10	NaCl + $CaCl_2·2H_2O$	1.0	NaCl	0.09	1.51	4.72	4.54	0.85
			$CaCl_2·2H_2O$	0.22				
11		3.0	NaCl	0.46	7.93	17.43	23.66	0.85
			$CaCl_2·2H_2O$	1.15				
12		4.5	NaCl	0.75	12.85	27.36	38.51	0.85
			$CaCl_2·2H_2O$	1.88				
13		6.0	NaCl	1.06	18.22	38.09	54.60	0.85
			$CaCl_2·2H_2O$	2.66				
14	Na_2SO_4	1.0	Na_2SO_4	0.35	4.98	1.70	0.0039	5.83
15		3.0		1.82	25.63	1.70	0.0039	26.48
16		4.5		2.98	41.99	1.70	0.0039	42.84
17		6.0		4.29	60.37	1.70	0.0039	61.21

*Includes 0.5 dS/m contributed by Hoagland's solution

#Includes meq/L contributed by 0.5 dS/m Hoagland's solution

Figure 2. Tree organization, irrigation treatment delivery and expanded metal pot stands.

Figure 3. Injector system. Red cans intended for concentrate tanks were replaced with 8L bottles.

Figure 4. Eight liter concentrate bottle supplying two injectors. Concentrate solution was agitated by pressurized air delivered through 0.635 cm black tubing.

Figure 5. Saucer under pot stand for leachate collection and bottle for irrigation treatment collection.

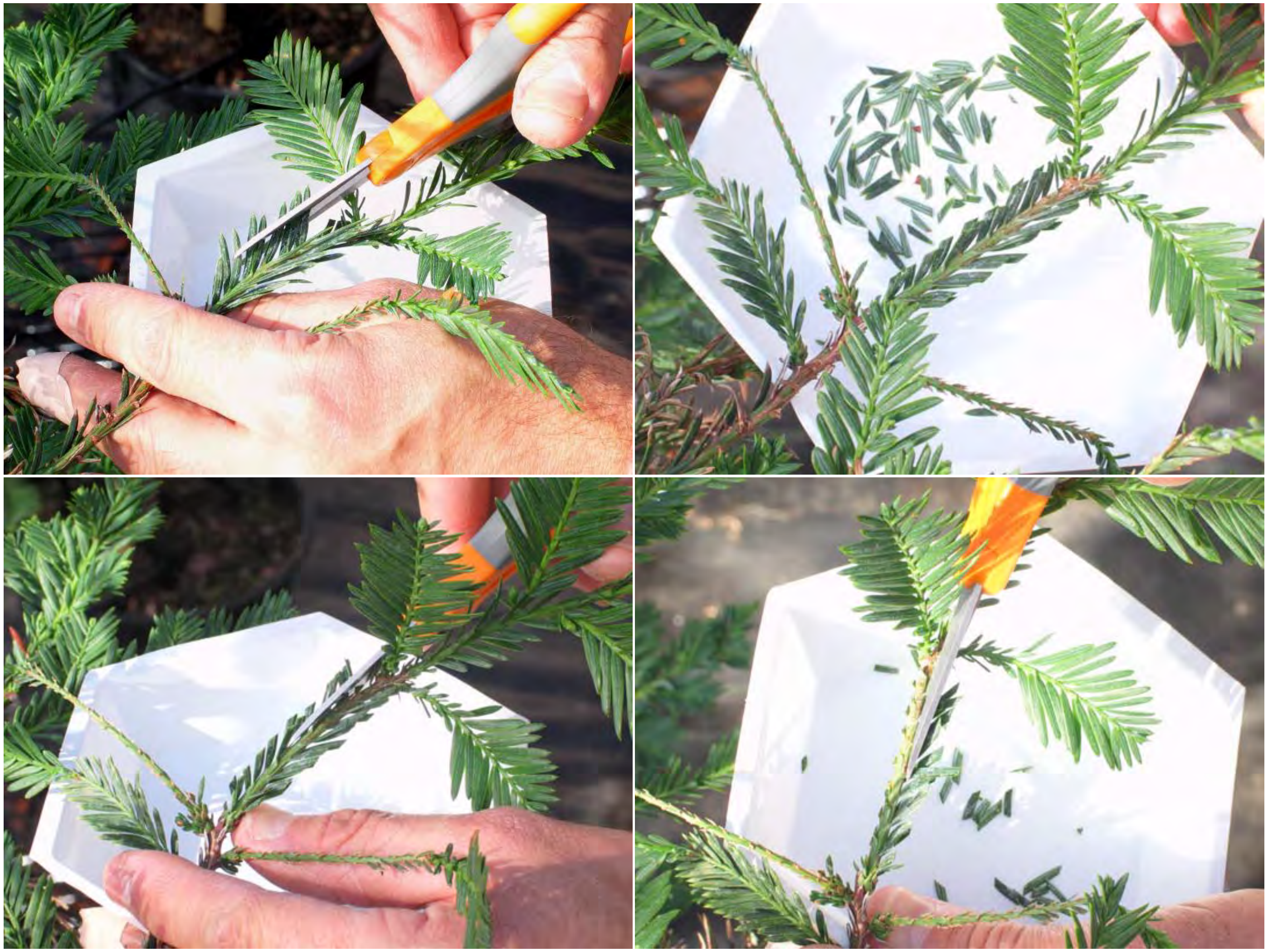

Figure 6. Leaf sampling procedure. Proximal leaf sections were collected and packaged first, followed by distal sections.

Table 3. Mean finalized treatment and leachate EC values.

Trt. no.	Salinity treatment and target EC	Mean treatment EC (dS/m) ± 1 SE	Mean leachate EC (dS/m) ± 1 SE
		12/7/2005 to 1/9/2007	
1	Control 0.5 dS/m	0.57 ± 0.01	0.66 ± 0.01
2	NaCl 1.0 dS/m	1.05 ± 0.01	1.67 ± 0.05
3	NaCl 3.0 dS/m	3.12 ± 0.03	4.52 ± 0.11
4	NaCl 4.5 dS/m	4.32 ± 0.05	5.71 ± 0.11
5	NaCl 6.0 dS/m	5.72 ± 0.08	7.08 ± 0.12
6	$CaCl_2$ 1.0 dS/m	1.06 ± 0.01	1.54 ± 0.02
7	$CaCl_2$ 3.0 dS/m	2.95 ± 0.02	5.08 ± 0.13
8	$CaCl_2$ 4.5 dS/m	4.52 ± 0.04	7.10 ± 0.16
9	$CaCl_2$ 6.0 dS/m	6.12 ± 0.04	8.83 ± 0.17
10	NaCl + $CaCl_2$ 1.0 dS/m	1.09 ± 0.01	1.61 ± 0.03
11	NaCl + $CaCl_2$ 3.0 dS/m	2.94 ± 0.03	4.60 ± 0.11
12	NaCl + $CaCl_2$ 4.5 dS/m	4.59 ± 0.03	6.83 ± 0.16
13	NaCl + $CaCl_2$ 6.0 dS/m	6.10 ± 0.04	8.40 ± 0.15
14	Na_2SO_4 1.0 dS/m	1.09 ± 0.01	1.73 ± 0.05
15	Na_2SO_4 3.0 dS/m	3.10 ± 0.04	4.68 ± 0.11
16	Na_2SO_4 4.5 dS/m	4.71 ± 0.01	6.08 ± 0.09
17	Na_2SO_4 6.0 dS/m	6.10 ± 0.02	7.37 ± 0.11

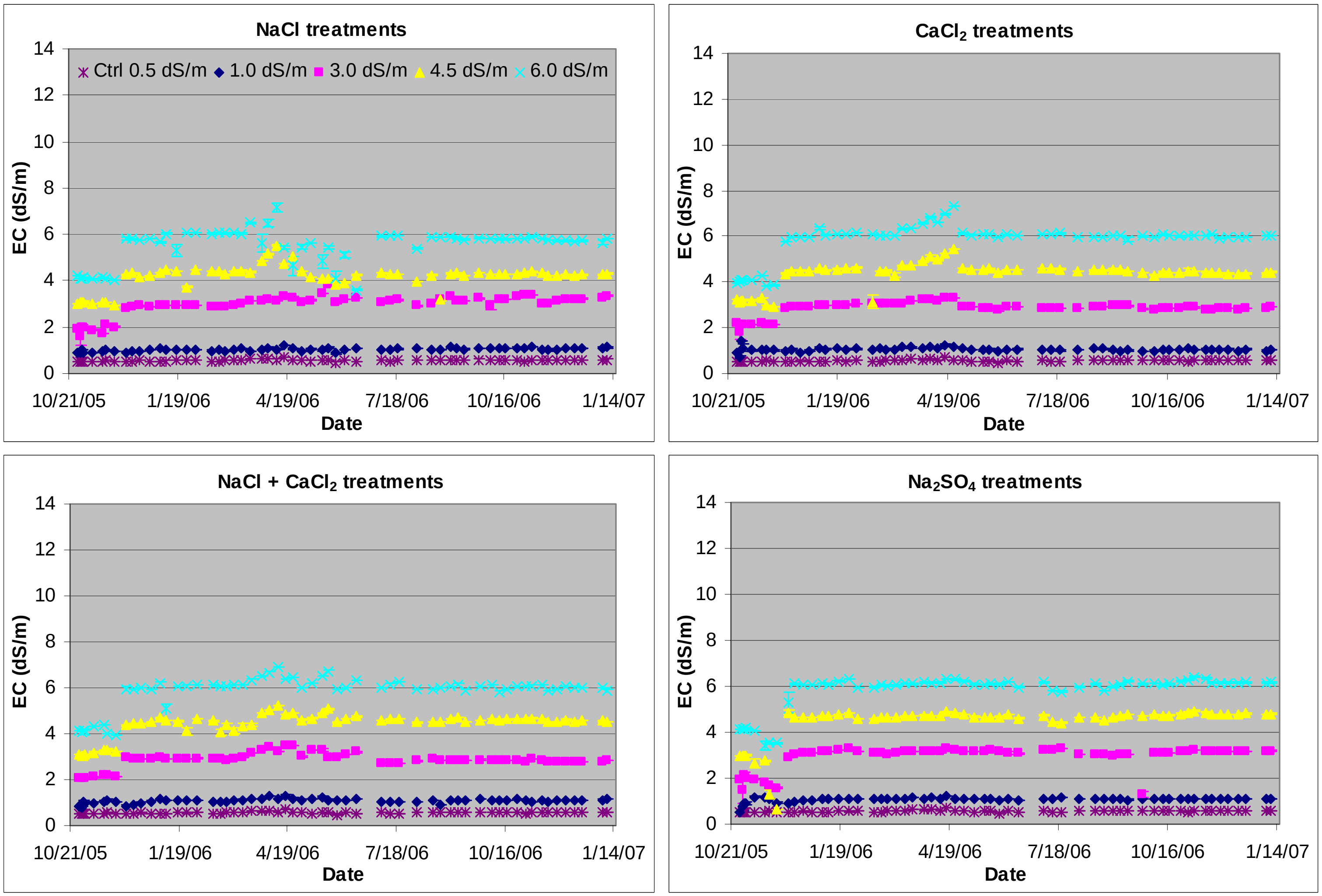

Figure 7. Mean EC (dS/m) by treatment over the experiment duration. Control treatment is repeated in each graph. Error bars indicate ± 1 SE.

Table 4. Treatment pH.

Trt. no.	Salinity type	EC (dS/m)*	pH
1	Control	0.5	5.3
2	NaCl	1.0	5.3
3		3.0	5.3
4		4.5	5.2
5		6.0	5.3
6	$CaCl_2 \cdot 2H_2O$	1.0	5.3
7		3.0	5.1
8		4.5	5.1
9		6.0	5.1
10	NaCl + $CaCl_2 \cdot 2H_2O$	1.0	5.3
11		3.0	5.3
12		4.5	5.3
13		6.0	5.3
14	Na_2SO_4	1.0	5.4
15		3.0	5.5
16		4.5	5.4
17		6.0	5.4

*EC for treatments 2-17 includes 0.5 dS/m Hoagland's solution

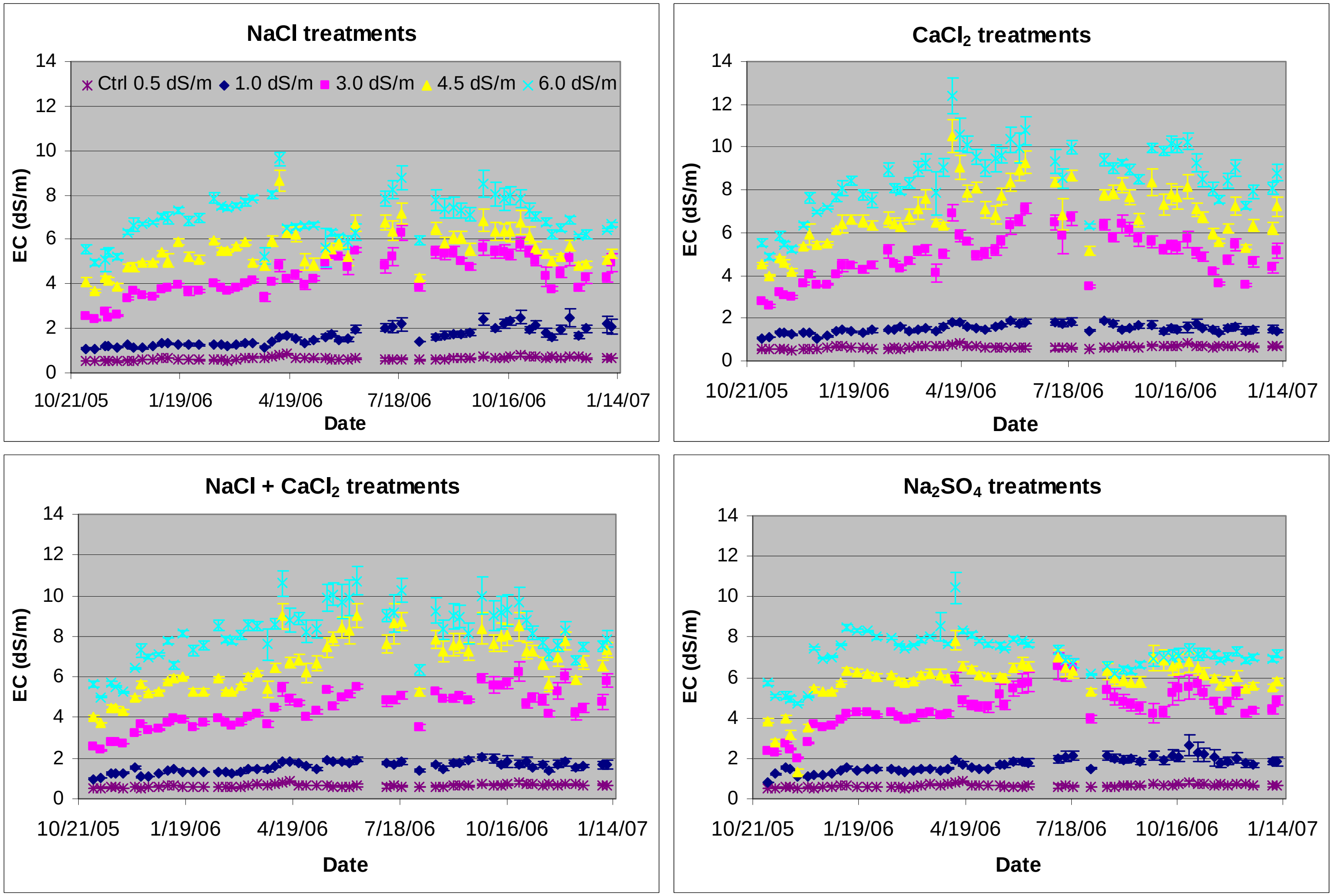

Figure 8. Mean leachate EC (dS/m) by treatment over the experiment duration. Control treatment is repeated in each graph. Error bars indicate ± 1 SE.

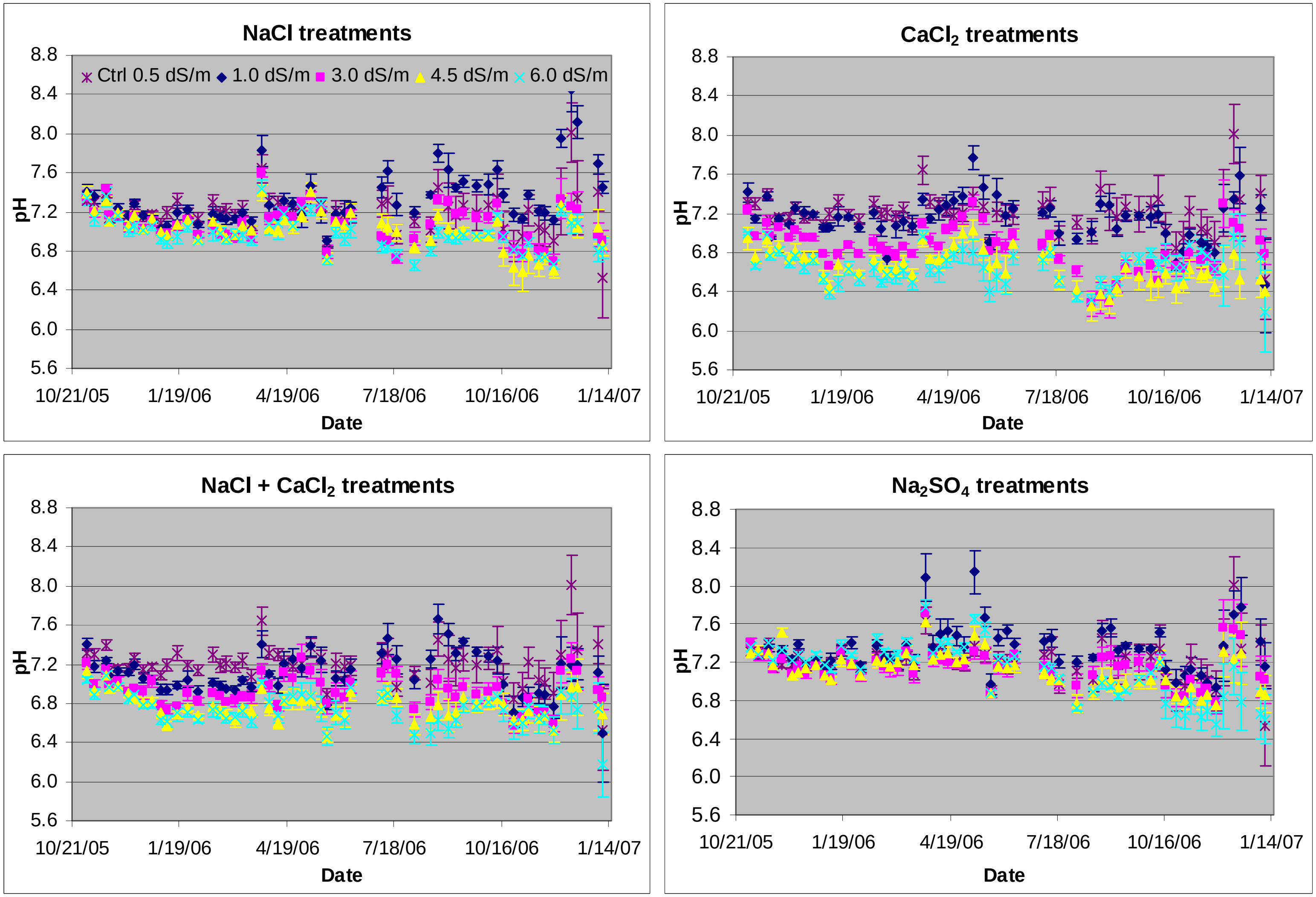

Figure 9. Mean leachate pH by treatment over the experiment duration. Control treatment is repeated in each graph. Error bars indicate ± 1 SE.

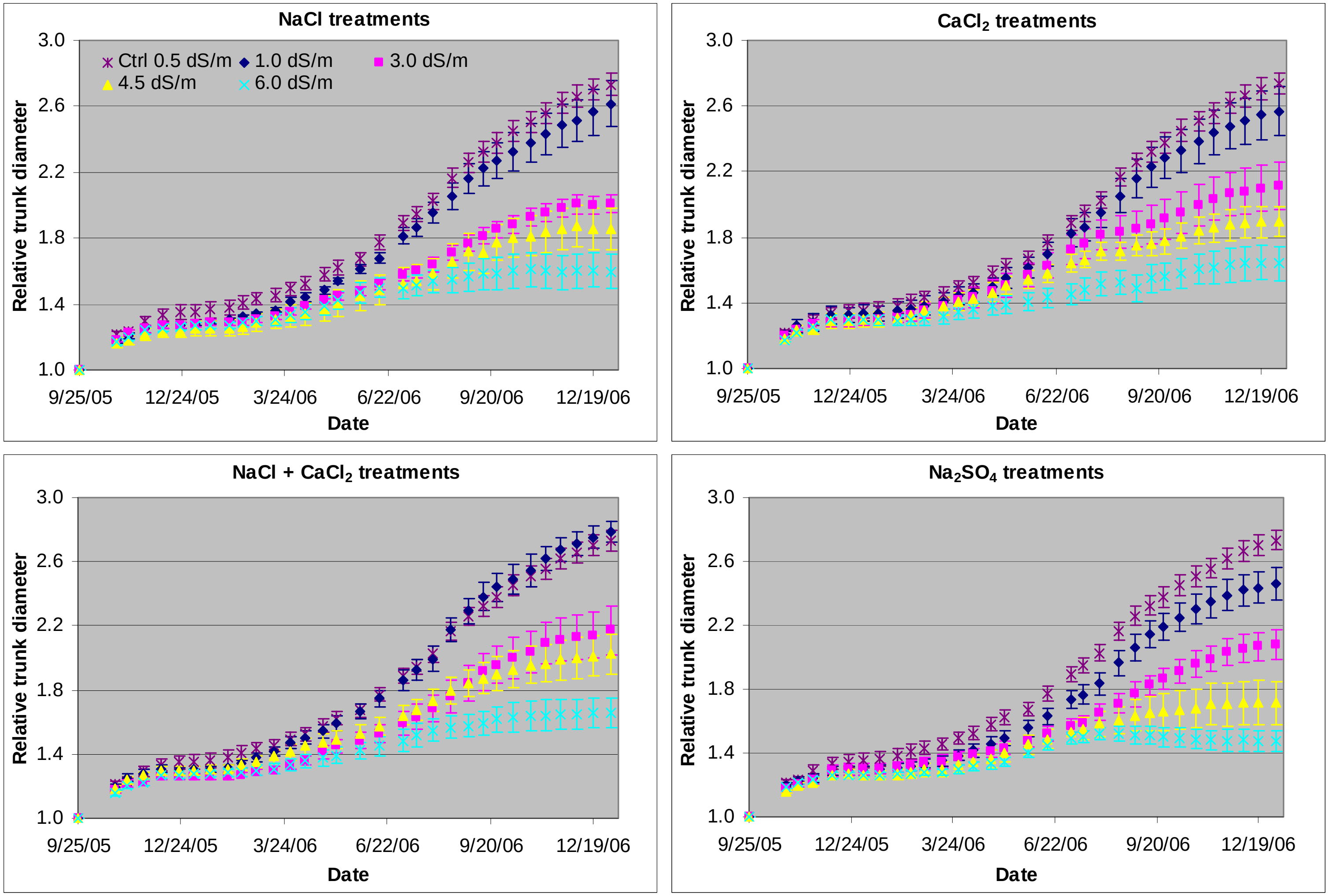

Figure 10. Relative trunk diameter by treatment over the experiment duration. Values were calculated by dividing each measurement for a replicate and date by the measurement from the same replicate on 9/25/05. Replicate values were then averaged within each treatment by date. Control treatment is repeated in each graph. Error bars indicate ± 1 SE.

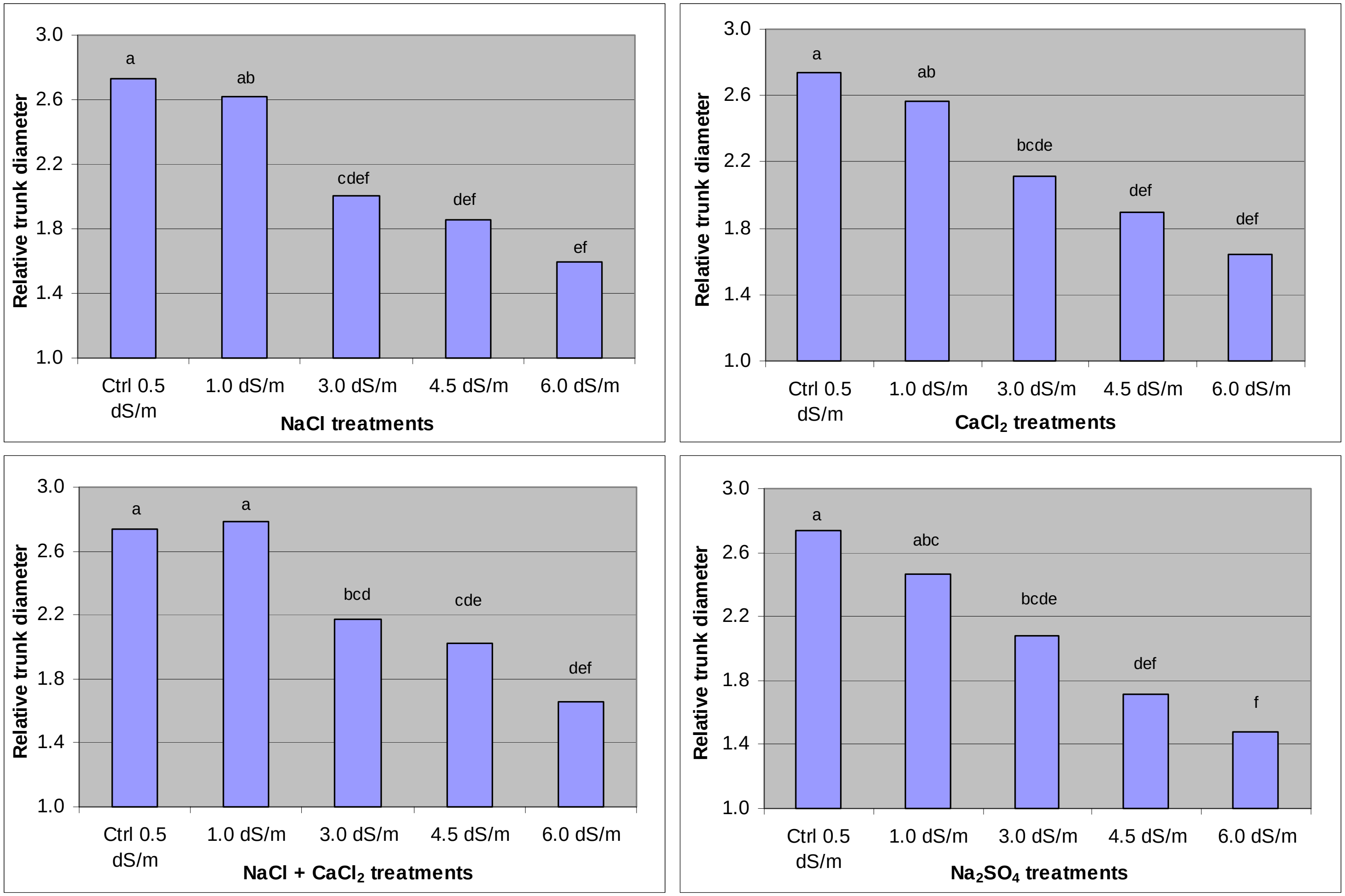

Figure 11. Relative trunk diameter by treatment. Values were calculated by dividing each measurement for a replicate on 1/3/07 by the measurement from the same replicate on 9/25/05. Replicate values were then averaged within each treatment. Control treatment is repeated in each graph. Tukey-Kramer mean separation analysis performed among all 17 treatments. Bars with like letters indicate lack of significance, $\alpha = 0.05$.

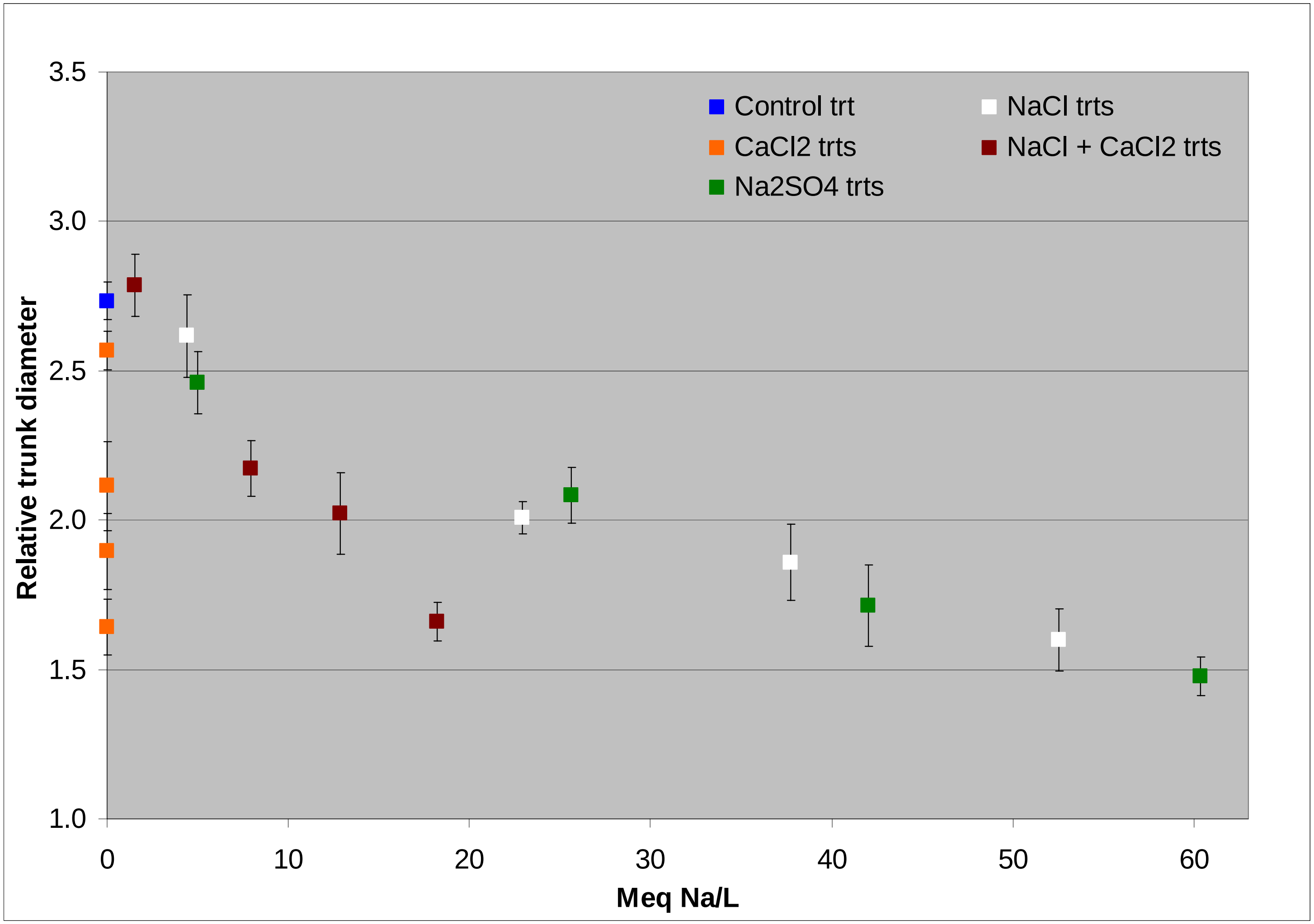

Figure 12. Relative trunk diameter as a function of meq Na/L for each irrigation treatment. An increase in meq Na/L or decrease in relative trunk diameter within a salinity type corresponds to an increase in the treatment EC (1.0, 3.0, 4.5, 6.0 dS/m). Values were calculated by dividing each measurement for a replicate on 1/3/07 by the measurement from the same replicate on 9/25/05. Replicate values were then averaged within each treatment. Error bars indicate ± 1 SE.

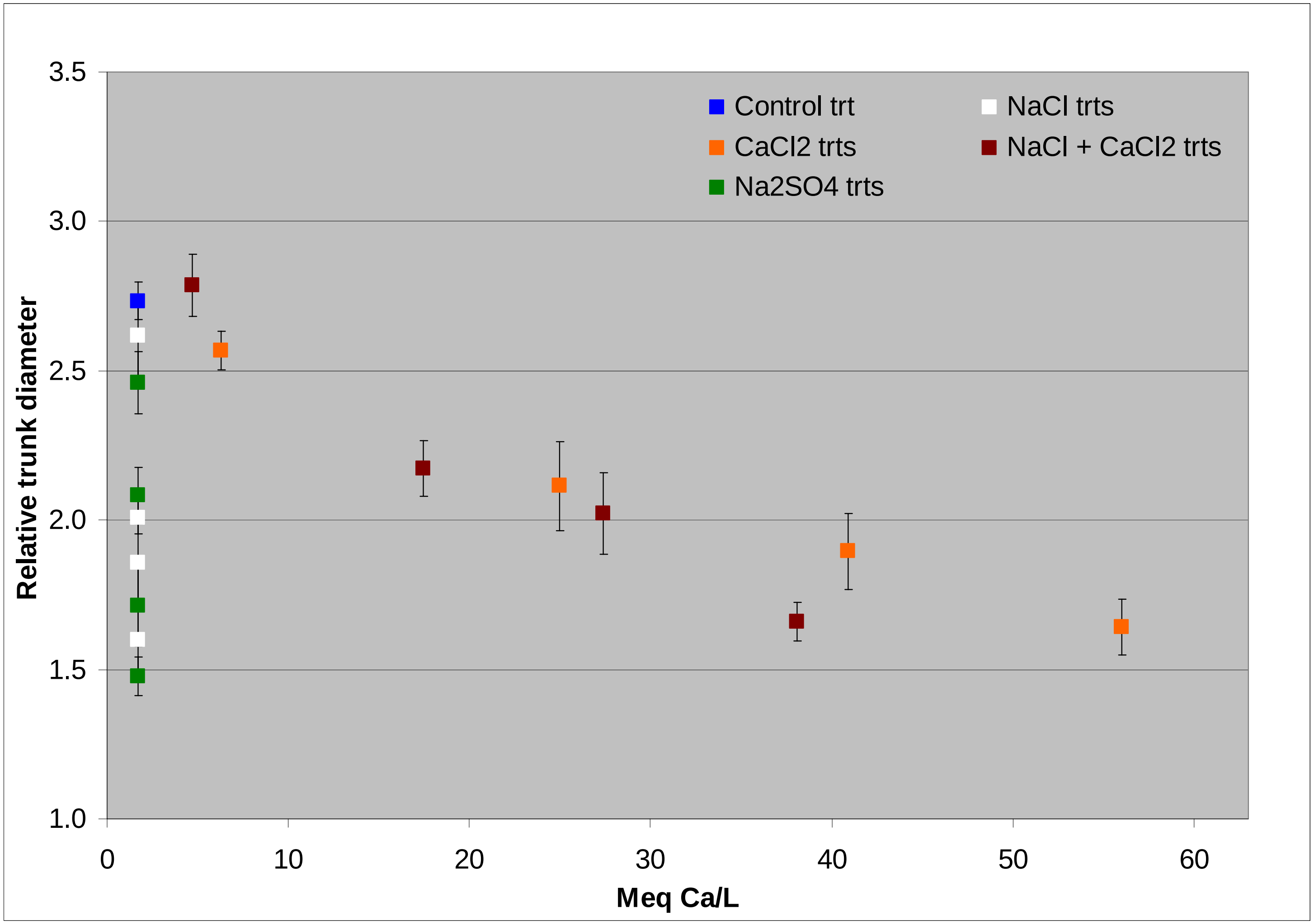

Figure 13. Relative trunk diameter as a function of meq Ca/L for each irrigation treatment. An increase in meq Ca/L or decrease in relative trunk diameter within a salinity type corresponds to an increase in the treatment EC (1.0, 3.0, 4.5, 6.0 dS/m). Values were calculated by dividing each measurement for a replicate on 1/3/07 by the measurement from the same replicate on 9/25/05. Replicate values were then averaged within each treatment. Error bars indicate ± 1 SE.

Table 5. Mean relative trunk diameter and tree height by treatment. Values are the mean of six replicates (9 replicates for the control) and were calculated by dividing the final measurement for given tree by the initial measurement. ANOVA $\alpha = 0.05$.

Treatment	Mean Relative Trunk Diameter ± 1 SE 9/25/2005 to 1/3/2007	Mean Relative Height ± 1 SE 9/15/2005 to 1/8/2007
Control 0.5 dS/m	2.73 ± 0.06	2.41 ± 0.22
NaCl 1.0 dS/m	2.62 ± 0.14	2.14 ± 0.23
NaCl 3.0 dS/m	2.01 ± 0.05	1.60 ± 0.13
NaCl 4.5 dS/m	1.86 ± 0.13	1.50 ± 0.13
NaCl 6.0 dS/m	1.60 ± 0.10	1.46 ± 0.17
$CaCl_2$ 1.0 dS/m	2.57 ± 0.15	2.10 ± 0.23
$CaCl_2$ 3.0 dS/m	2.11 ± 0.14	2.09 ± 0.12
$CaCl_2$ 4.5 dS/m	1.90 ± 0.09	2.05 ± 0.18
$CaCl_2$ 6.0 dS/m	1.64 ± 0.10	1.56 ± 0.10
NaCl + $CaCl_2$ 1.0 dS/m	2.79 ± 0.06	2.02 ± 0.30
NaCl + $CaCl_2$ 3.0 dS/m	2.17 ± 0.15	1.70 ± 0.27
NaCl + $CaCl_2$ 4.5 dS/m	2.02 ± 0.13	1.56 ± 0.12
NaCl + $CaCl_2$ 6.0 dS/m	1.66 ± 0.09	1.70 ± 0.15
Na_2SO_4 1.0 dS/m	2.46 ± 0.10	2.17 ± 0.23
Na_2SO_4 3.0 dS/m	2.08 ± 0.09	2.07 ± 0.26
Na_2SO_4 4.5 dS/m	1.71 ± 0.14	1.60 ± 0.15
Na_2SO_4 6.0 dS/m	1.48 ± 0.07	1.43 ± 0.12
ANOVA		
Block	$F = 6.36, P = 0.0139$	$F = 2.91, P = 0.0924$
Trt	$F = 16.47, P < 0.0001$	$F = 2.32, P = 0.0083$

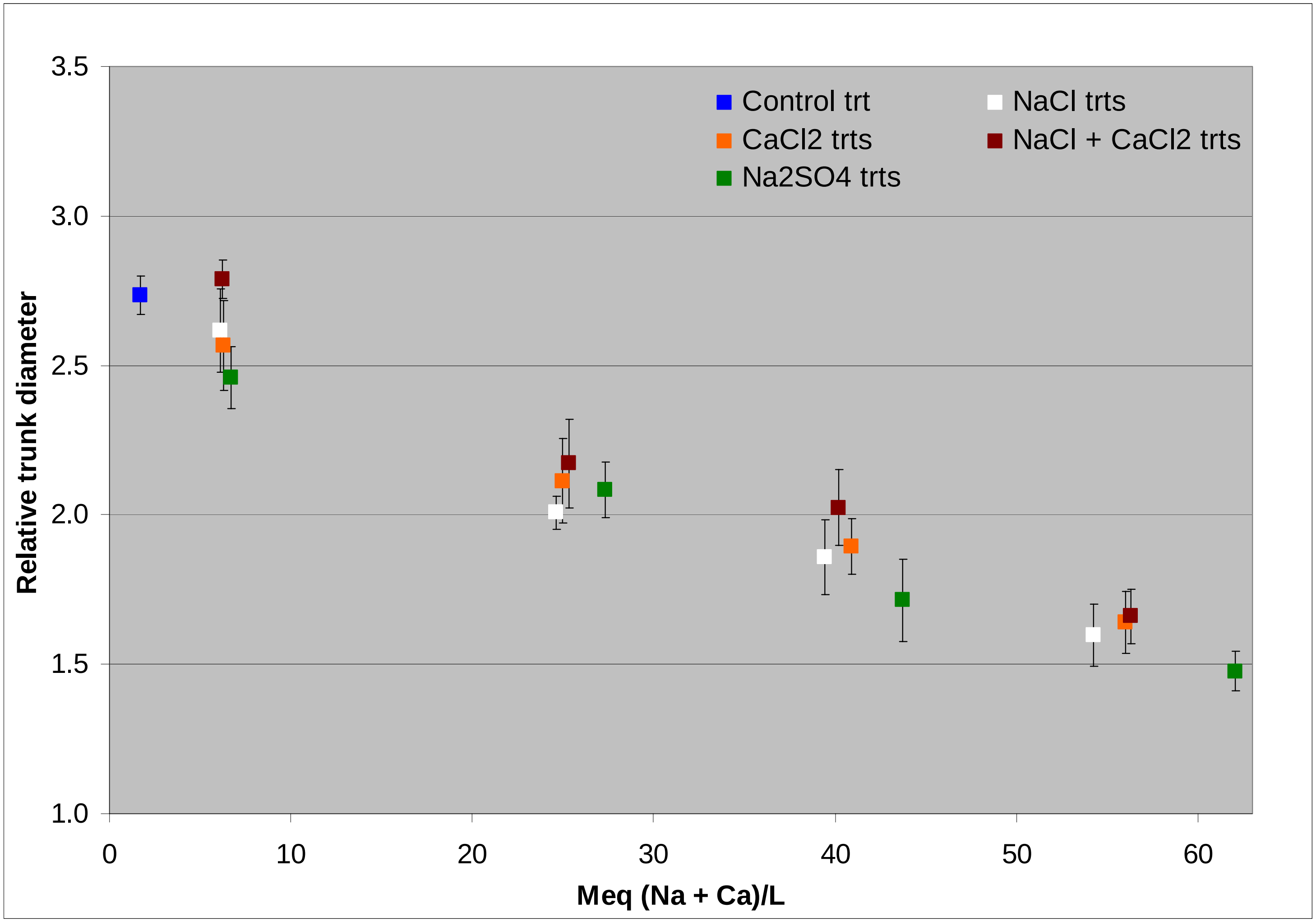

Figure 14. Relative trunk diameter as a function of meq (Na + Ca)/L for each irrigation treatment. An increase in meq Na + Ca/L or decrease in relative trunk diameter within a salinity type corresponds to an increase in the treatment EC (1.0, 3.0, 4.5, 6.0 dS/m). Values were calculated by dividing each measurement for a replicate on 1/3/07 by the measurement from the same replicate on 9/25/05. Replicate values were then averaged within each treatment. Error bars indicate ± 1 SE.

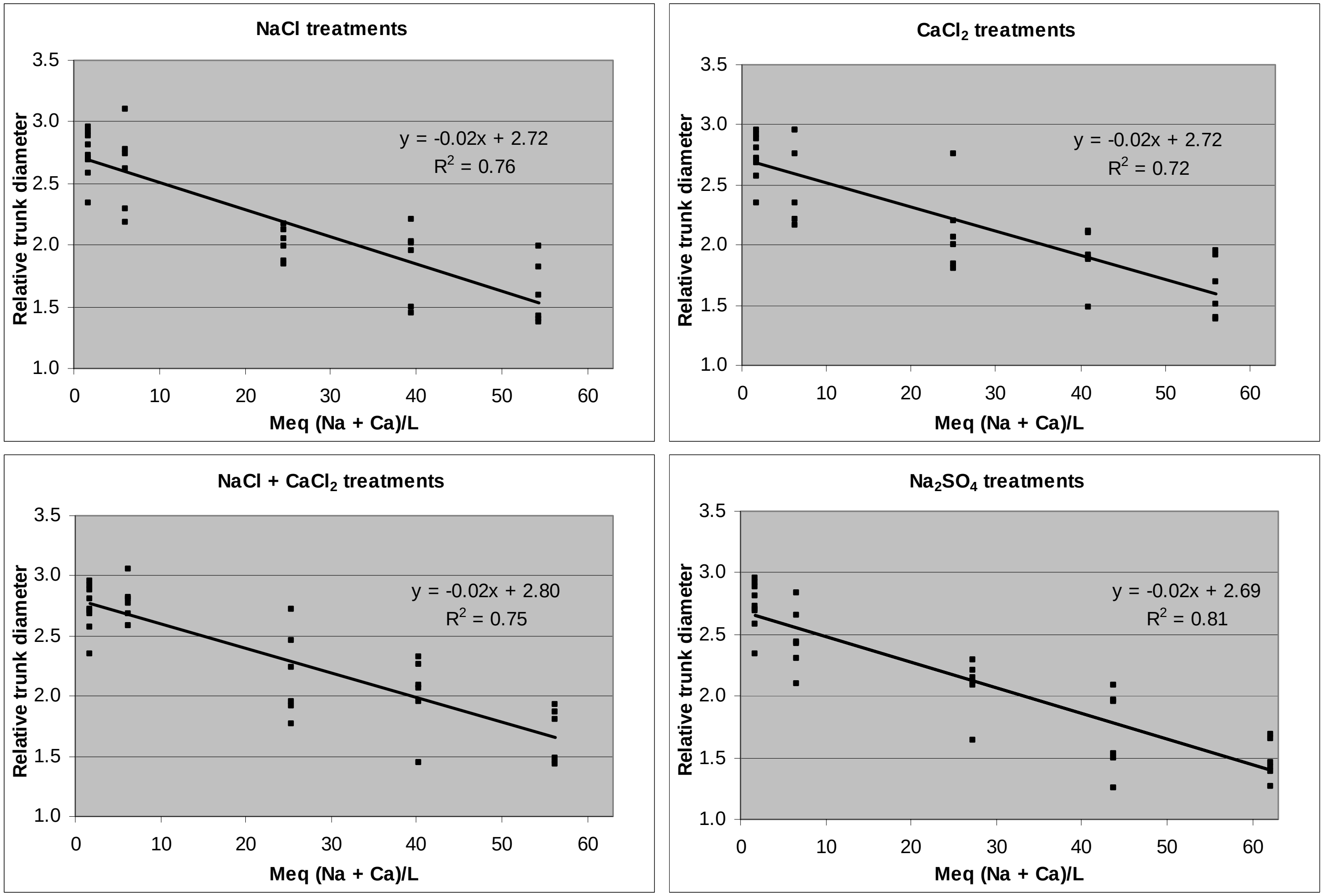

Figure 15. Relative trunk diameter as a function of meq (Na + Ca)/L for each replicate by irrigation treatment. An increase in meq (Na + Ca)/L or decrease in relative trunk diameter within a salinity type corresponds to an increase in the treatment EC (1.0, 3.0, 4.5, 6.0 dS/m). Values were calculated by dividing each measurement for a replicate on 1/3/07 by the measurement from the same replicate on 9/25/05. Control treatment values are the leftmost vertical group of points and are repeated in each graph.

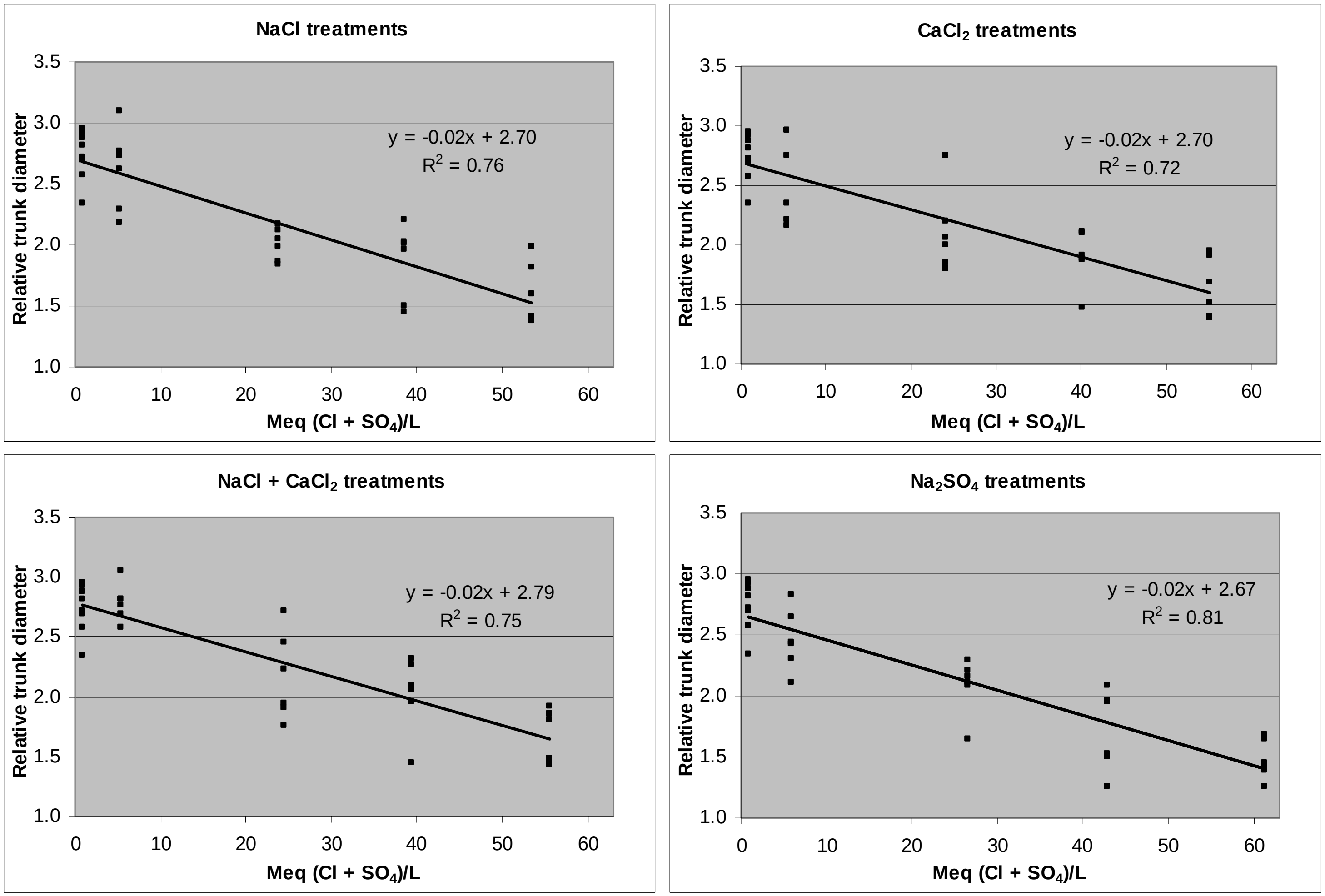

Figure 16. Relative trunk diameter as a function of meq (Cl + SO_4)/L for each replicate by irrigation treatment. An increase in meq (Cl + SO_4)/L or decrease in relative trunk diameter within a salinity type corresponds to an increase in the treatment EC (1.0, 3.0, 4.5, 6.0 dS/m). Values were calculated by dividing each measurement for a replicate on 1/3/07 by the measurement from the same replicate on 9/25/05. Control treatment values are the leftmost vertical group of points and are repeated in each graph.

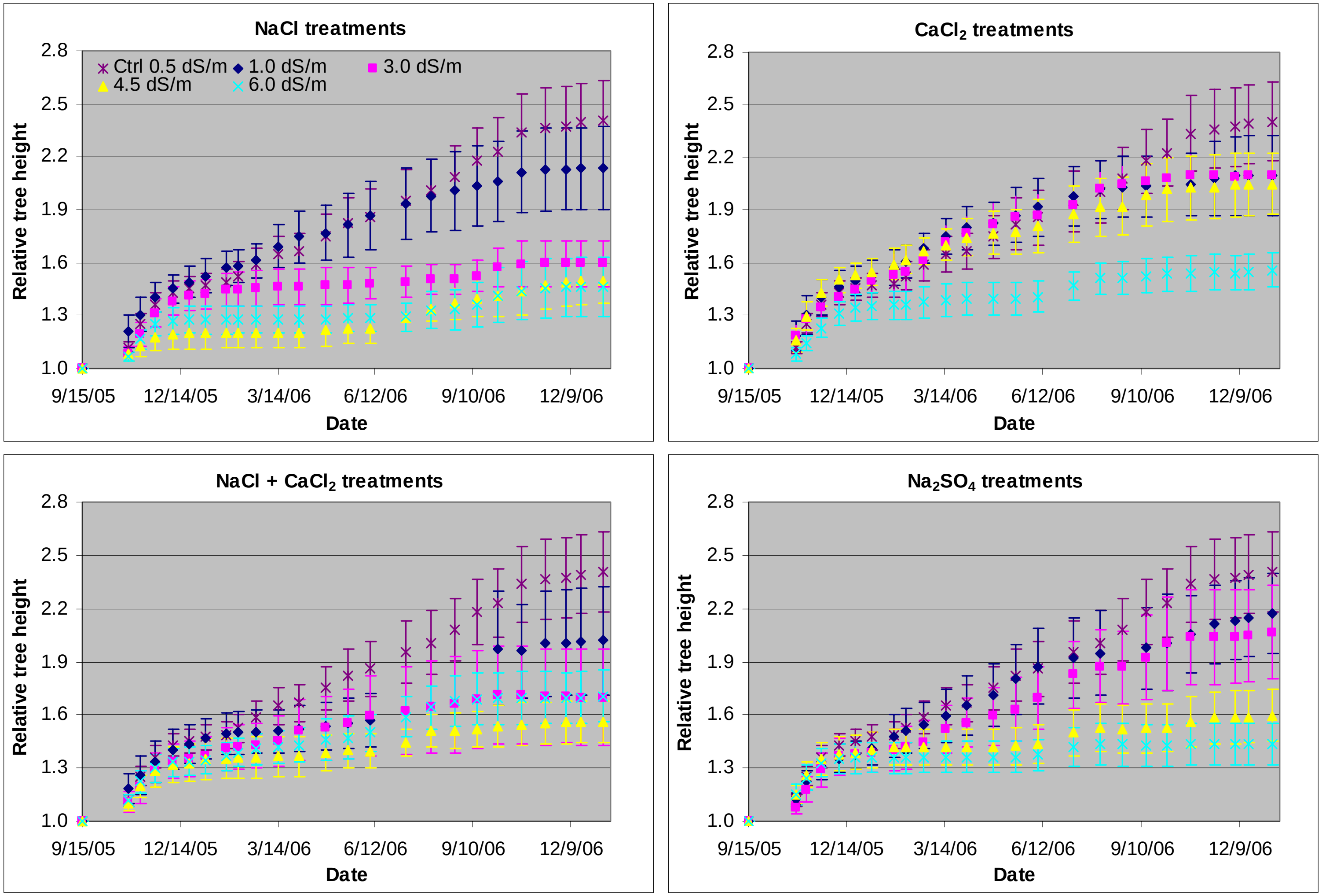

Figure 17. Relative tree height by treatment over the experiment duration. Values were calculated by dividing each measurement for a replicate and date by the measurement from the same replicate on 9/15/05. Replicate values were then averaged within each treatment by date. Control treatment is repeated in each graph. Error bars indicate ± 1 SE.

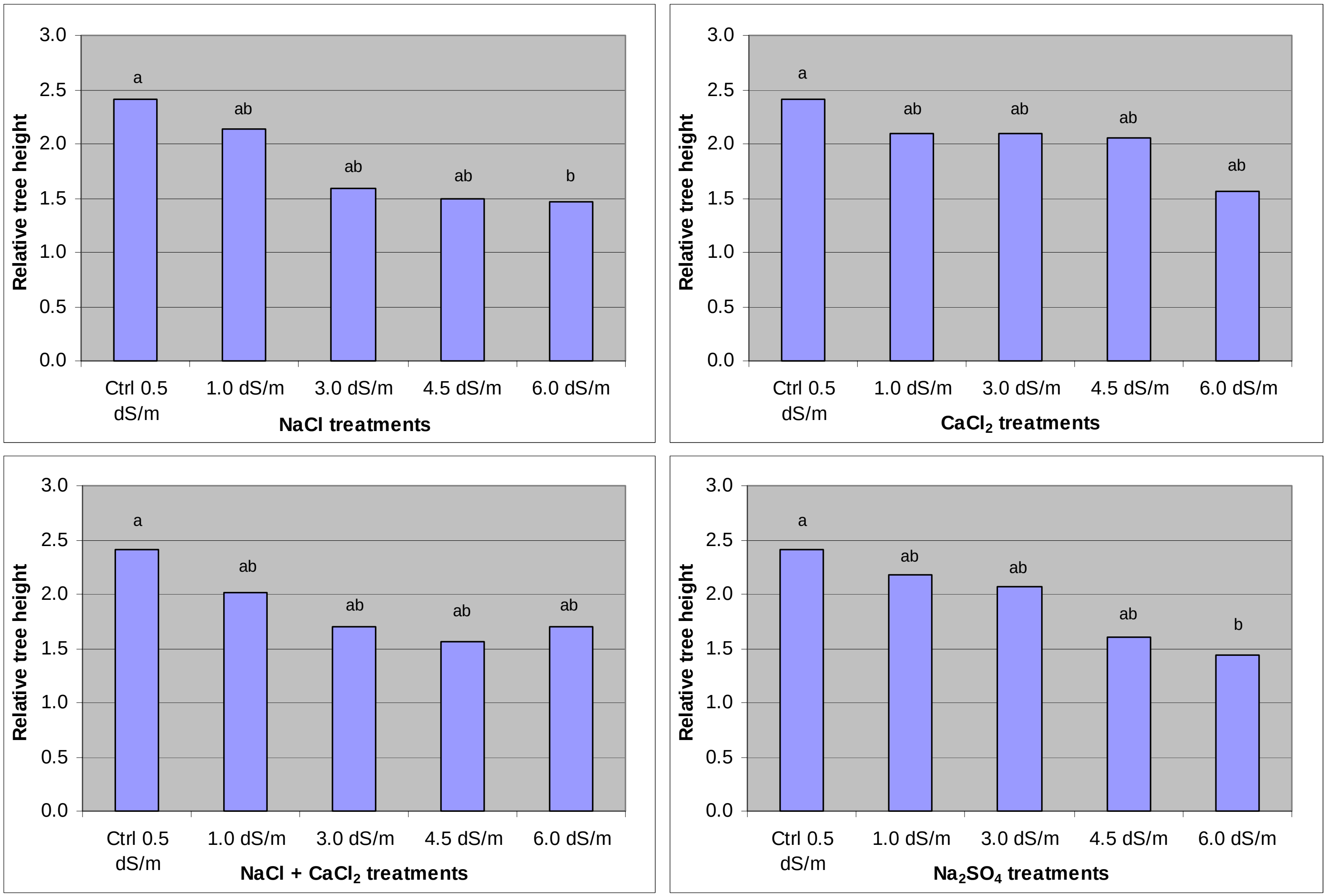

Figure 18. Relative tree height by treatment. Values were calculated by dividing each measurement for a replicate on 1/8/07 by the measurement from the same replicate on 9/15/05. Replicate values were then averaged within each treatment. Control treatment is repeated in each graph. Tukey-Kramer mean separation analysis performed among all 17 treatments. Bars with like letters indicate lack of significance, $\alpha = 0.05$.

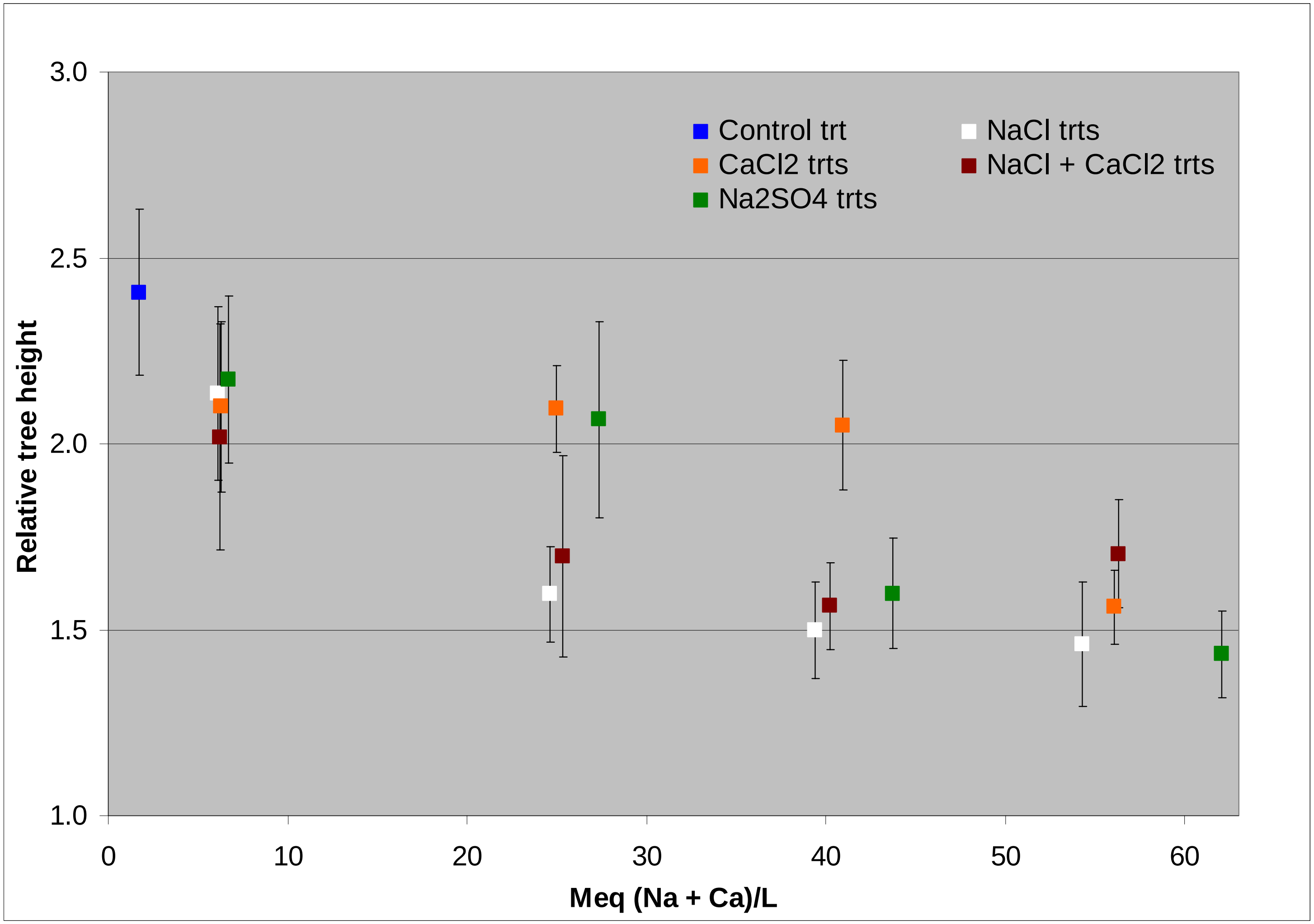

Figure 19. Relative tree height as a function of meq (Na + Ca)/L for each irrigation treatment. An increase in meq (Na + Ca)/L or decrease in relative trunk diameter within a salinity type corresponds to an increase in the treatment EC (1.0, 3.0, 4.5, 6.0 dS/m). Values were calculated by dividing each measurement for a replicate on 1/8/07 by the measurement from the same replicate on 9/15/05. Replicate values were then averaged within each treatment. Error bars indicate ± 1 SE.

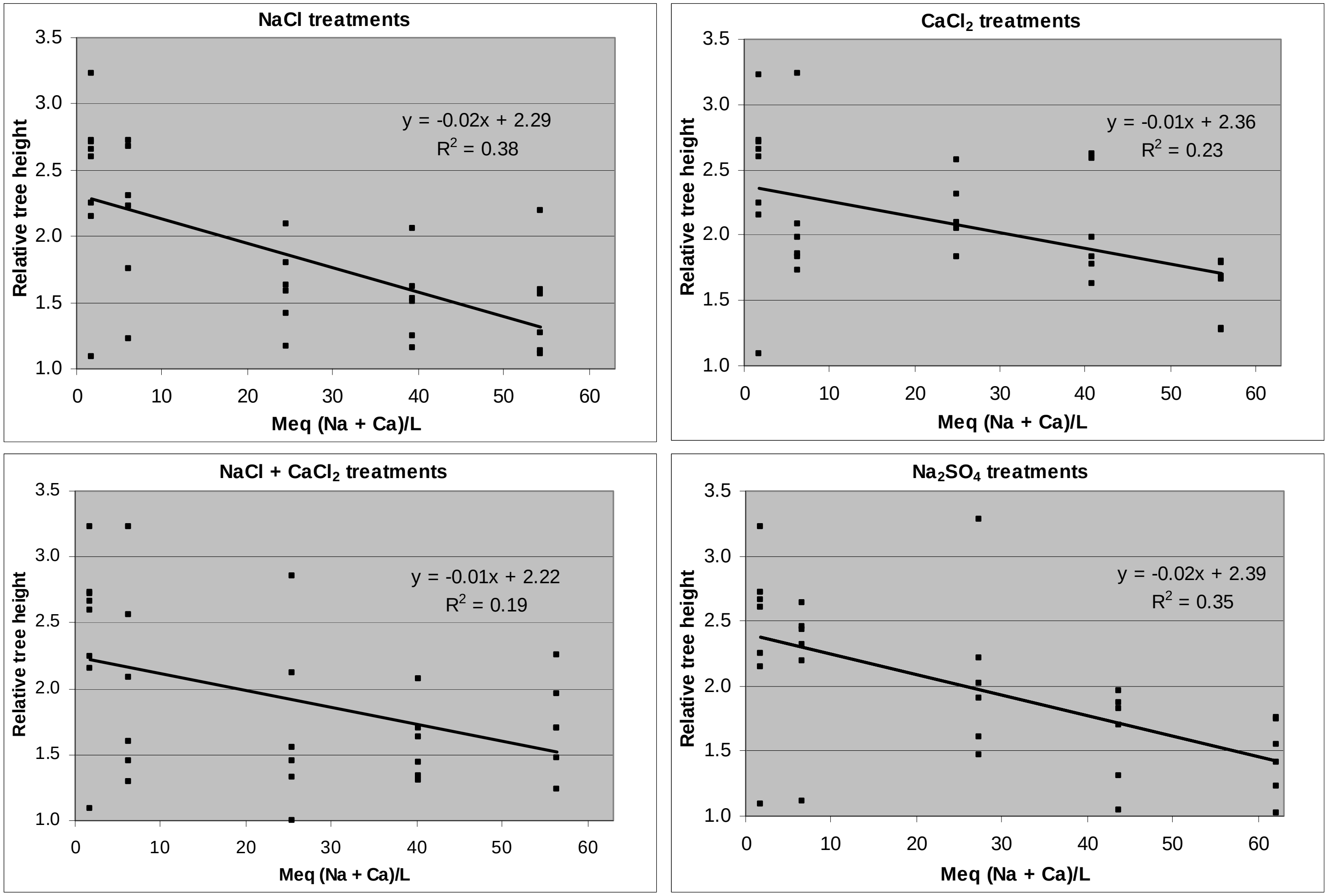

Figure 20. Relative tree height as a function of meq (Na + Ca)/L for each replicate by irrigation treatment. An increase in meq (Na + Ca)/L or decrease in relative tree height within a salinity type corresponds to an increase in the treatment EC (1.0, 3.0, 4.5, 6.0 dS/m). Values were calculated by dividing each measurement for a replicate on 1/8/07 by the measurement from the same replicate on 9/15/05. Control treatment values are the leftmost vertical group of points and are repeated in each graph.

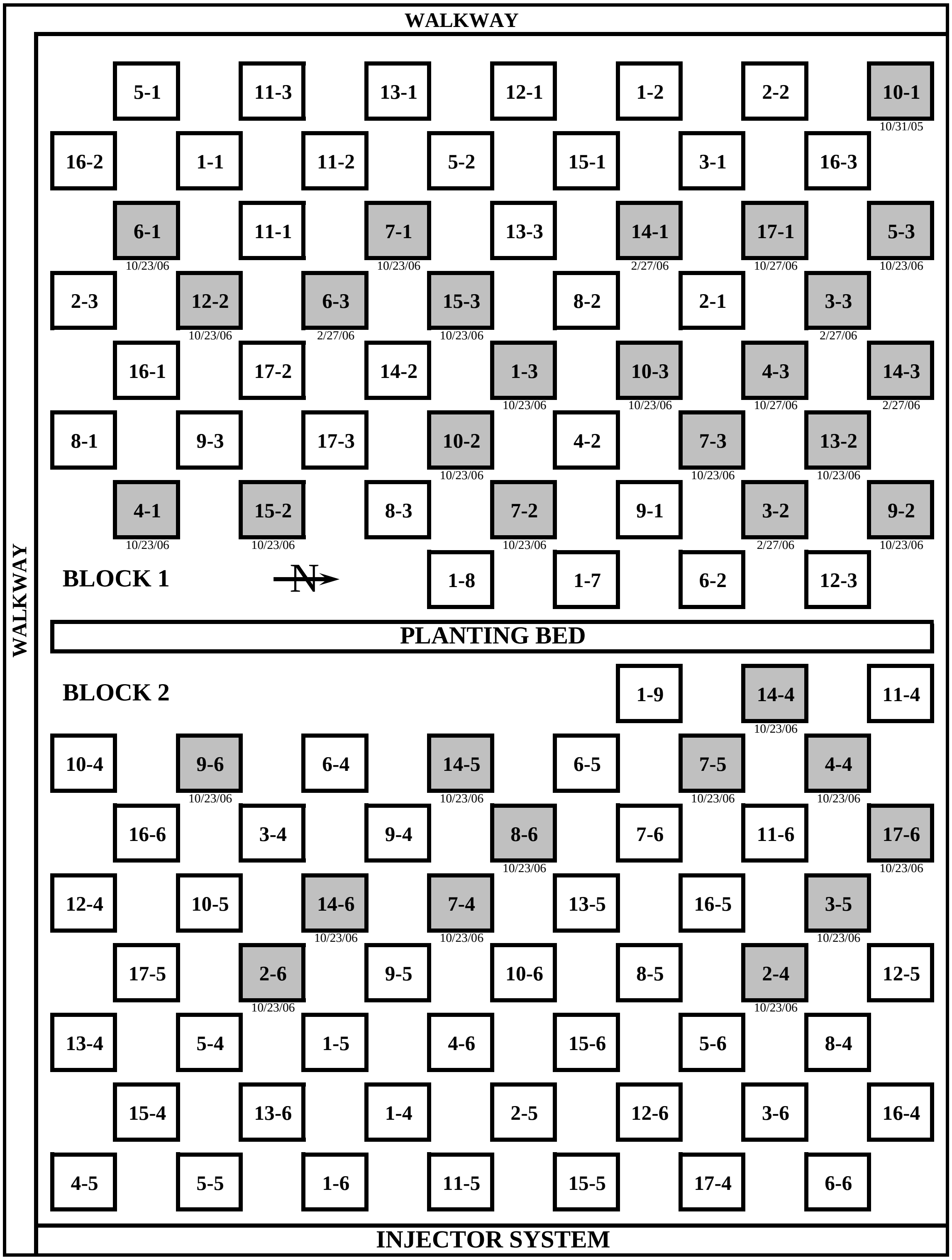

Figure 21. Trees moved in greenhouse. Affected trees are indicated as gray squares, with the exchange date listed below the square.

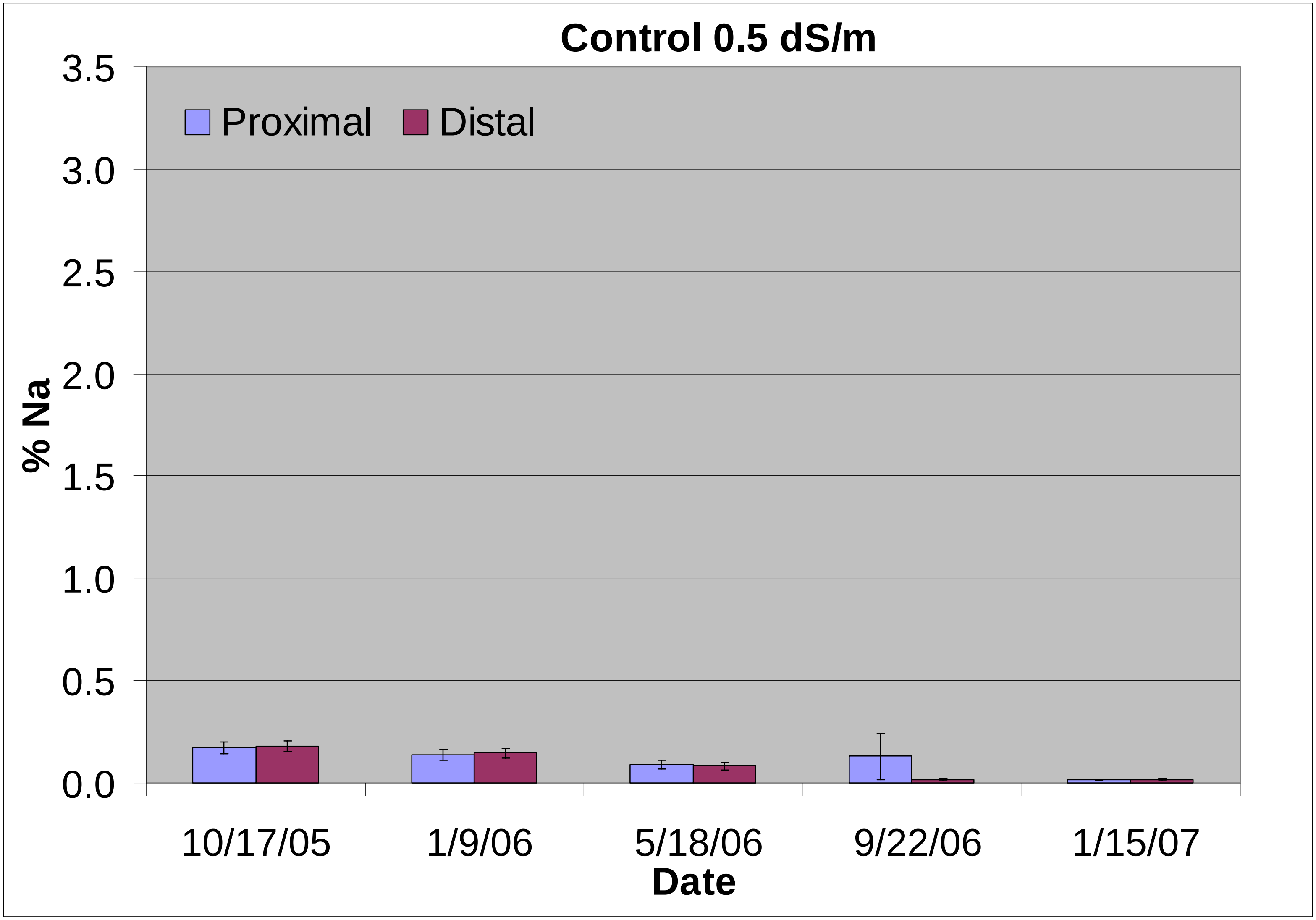

Figure 22. Leaf tissue mean % Na by section for the control treatment across five sampling dates. Error bars indicate ± 1 SE.

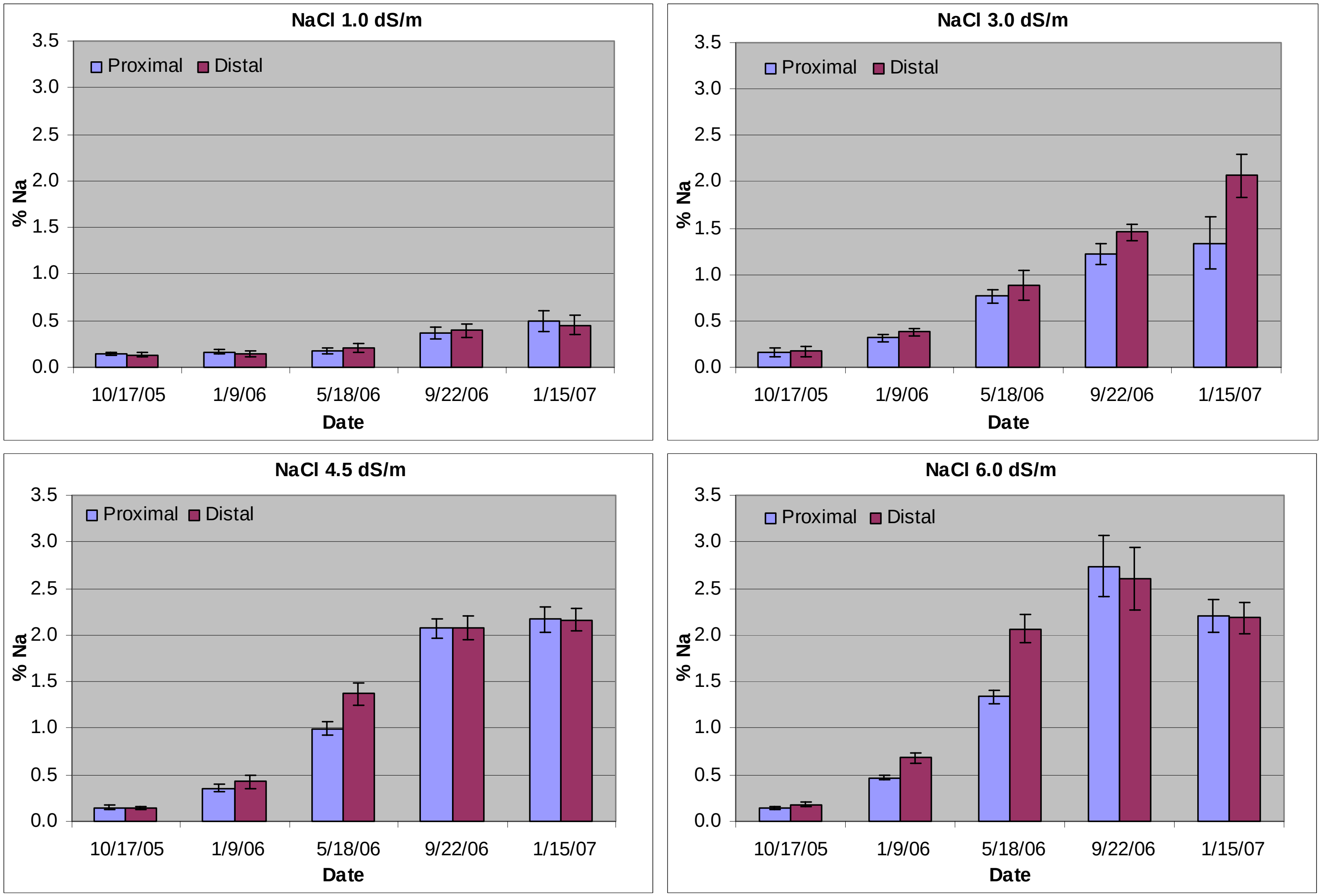

Figure 23. Leaf tissue mean % Na by section for the NaCl treatments across five sampling dates. Error bars indicate ± 1 SE.

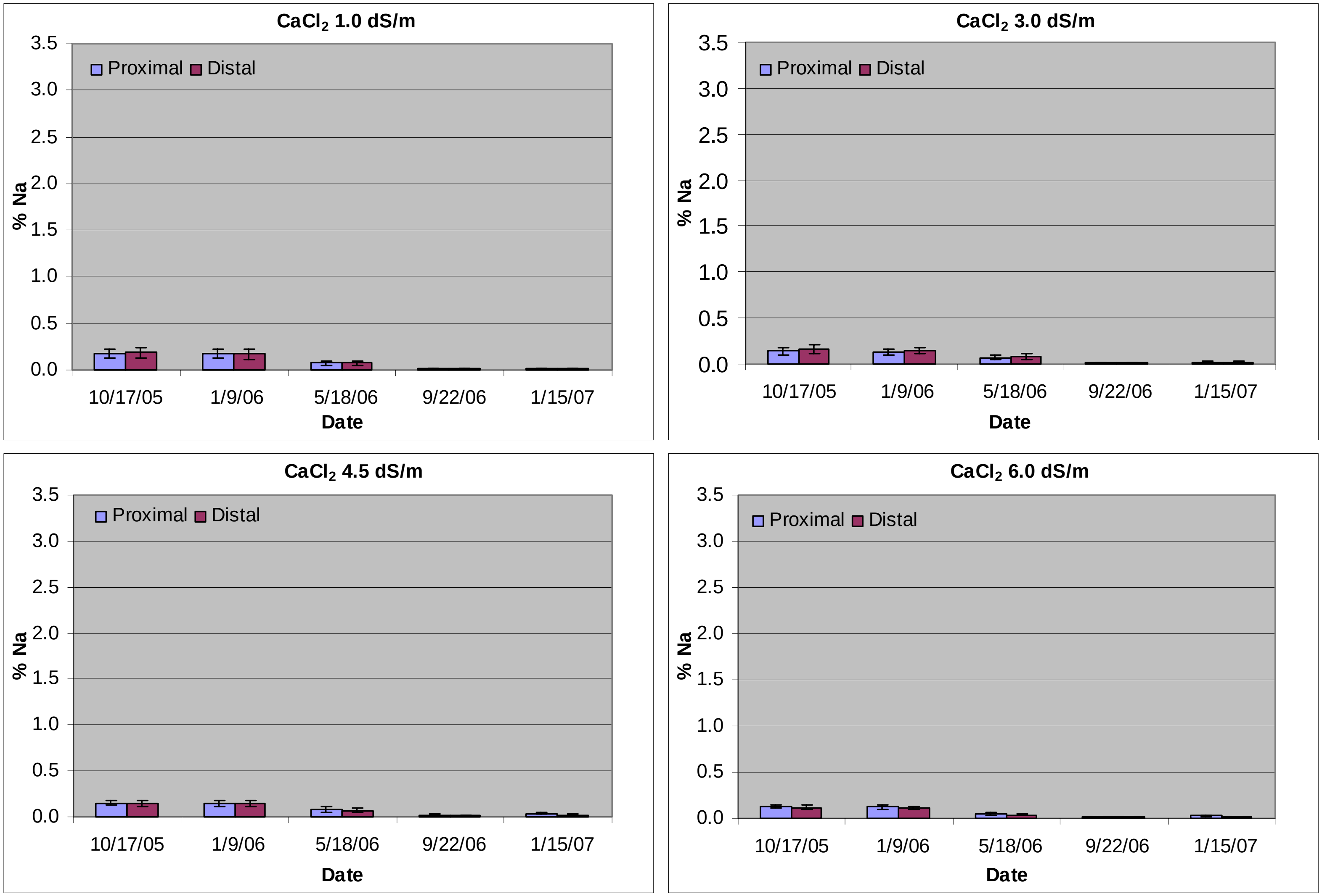

Figure 24. Leaf tissue mean % Na by section for the $CaCl_2$ treatments across five sampling dates. Error bars indicate ± 1 SE.

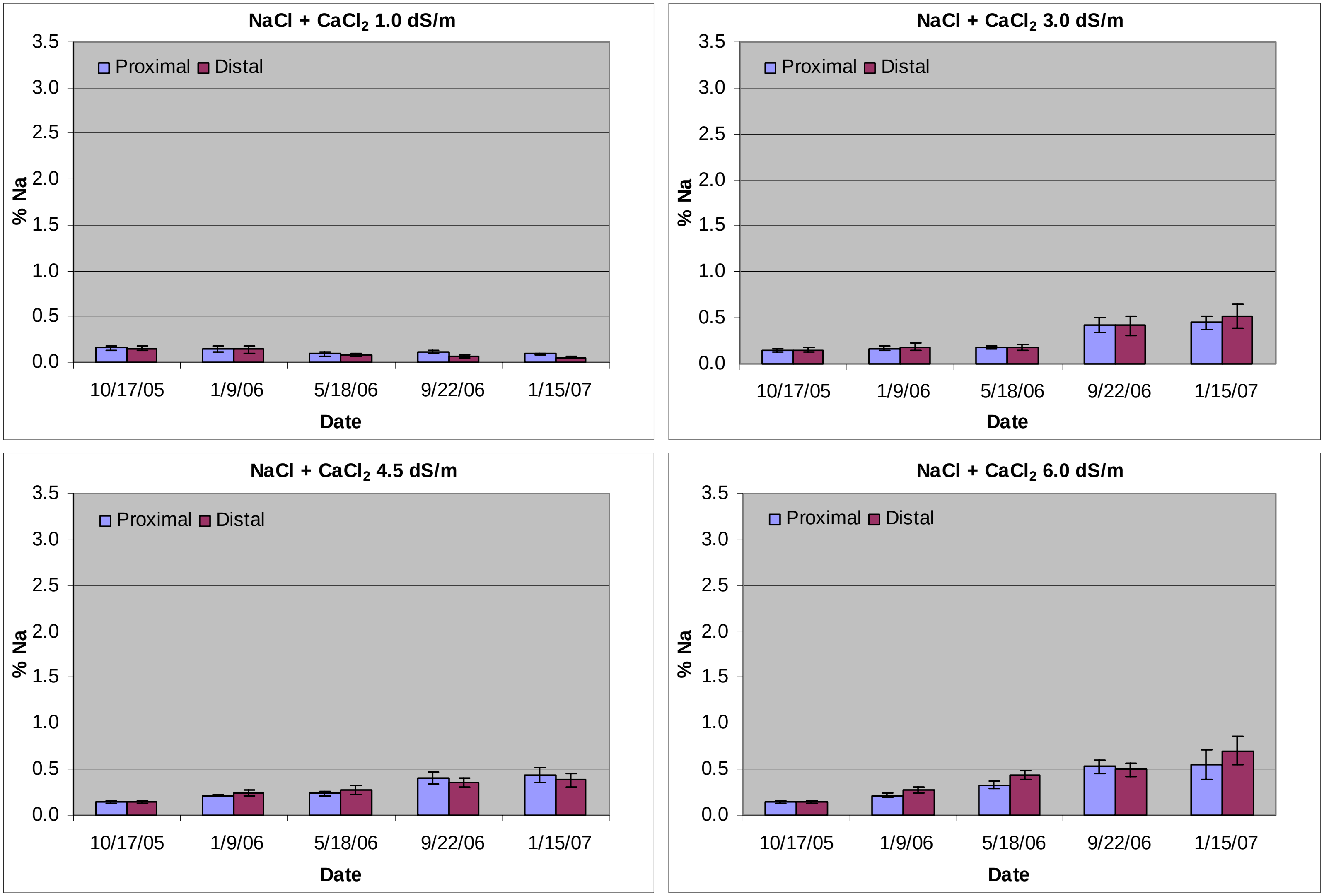

Figure 25. Leaf tissue mean % Na by section for the NaCl + $CaCl_2$ treatments across five sampling dates. Error bars indicate ± 1 SE.

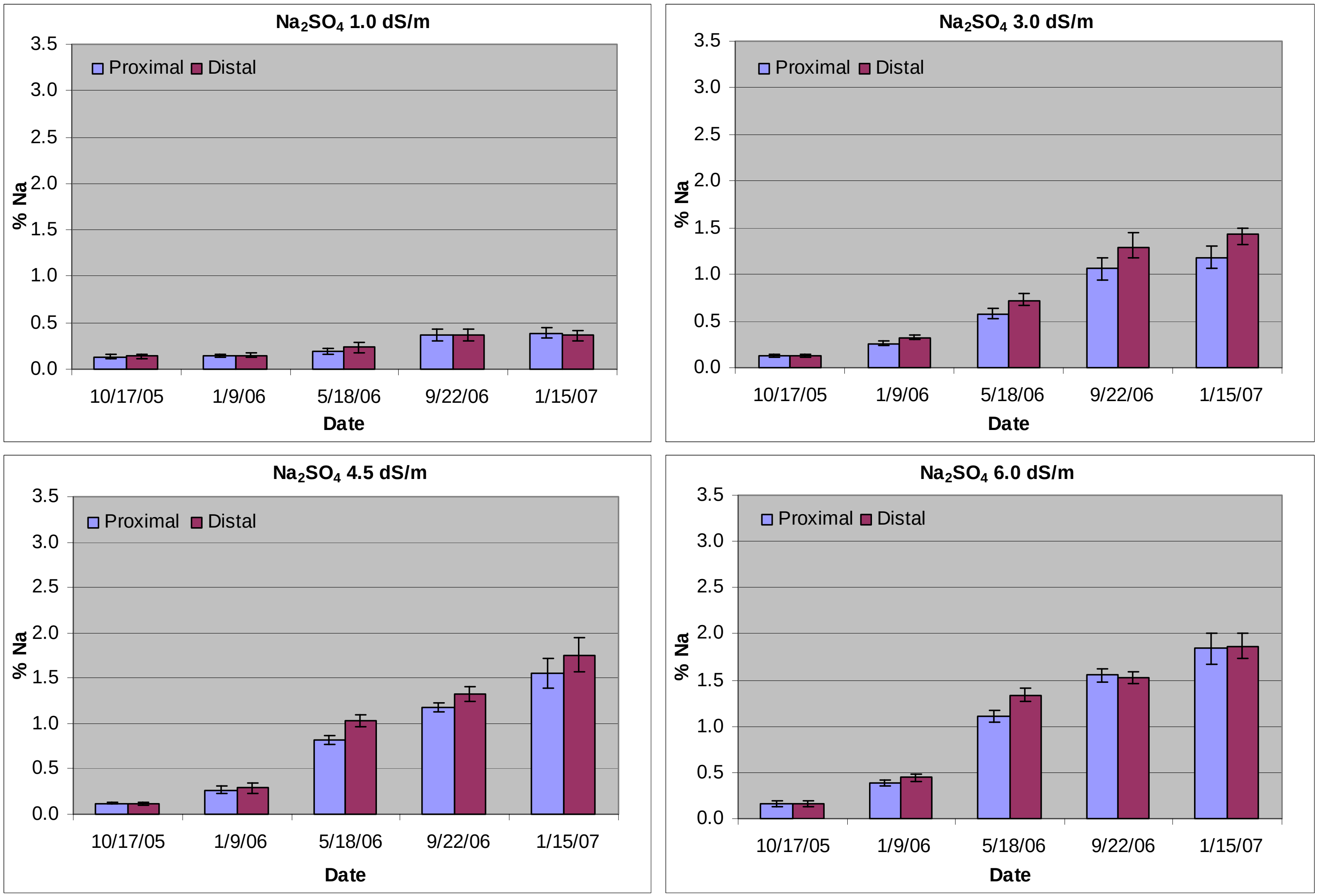

Figure 26. Leaf tissue mean % Na by section for the Na_2SO_4 treatments across five sampling dates. Error bars indicate ± 1 SE.

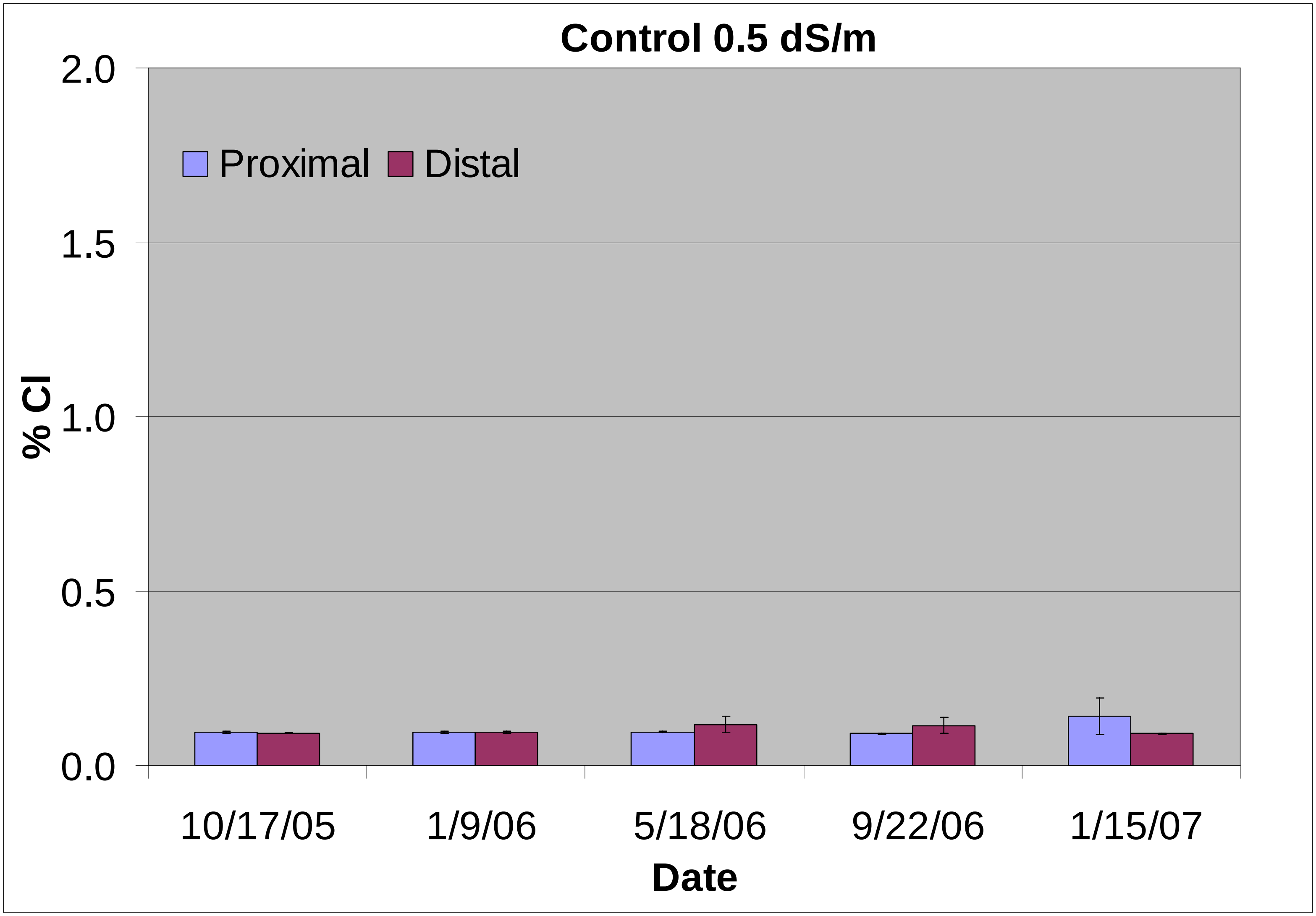

Figure 27. Leaf tissue mean % Cl by section for the control treatment across five sampling dates. Error bars indicate ± 1 SE.

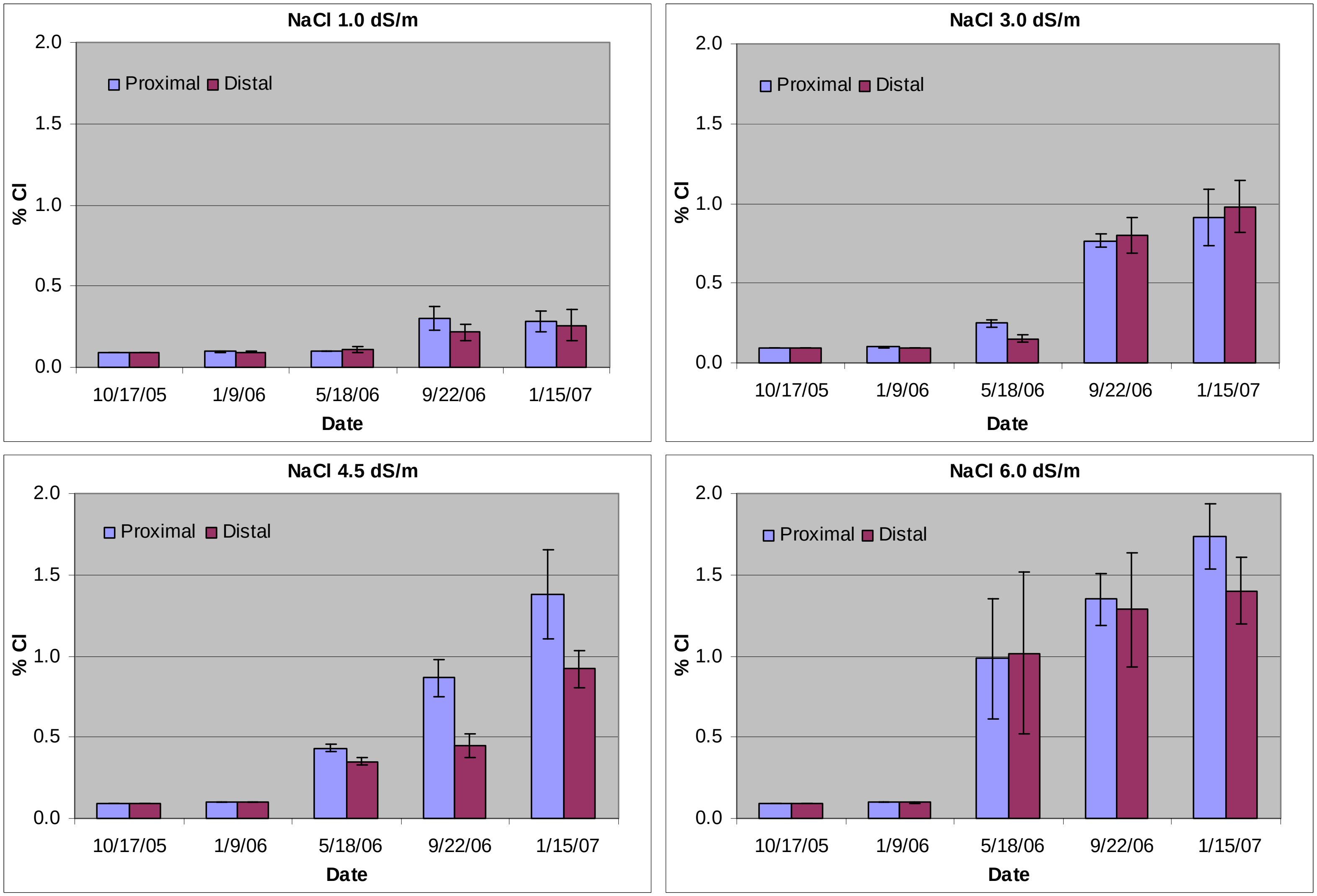

Figure 28. Leaf tissue mean % Cl by section for the NaCl treatments across five sampling dates. Error bars indicate ± 1 SE.

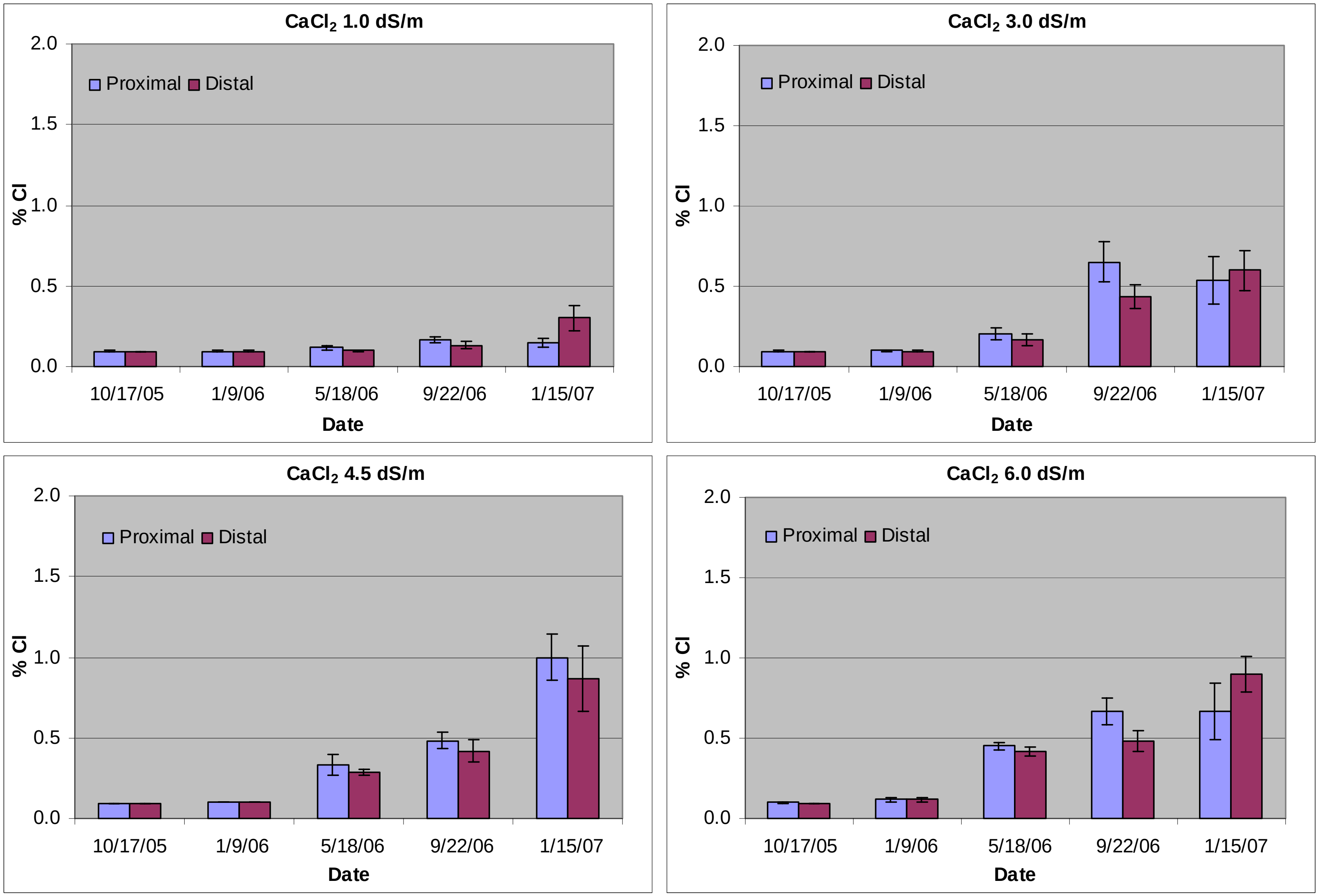

Figure 29. Leaf tissue mean % Cl by section for the $CaCl_2$ treatments across five sampling dates. Error bars indicate ± 1 SE.

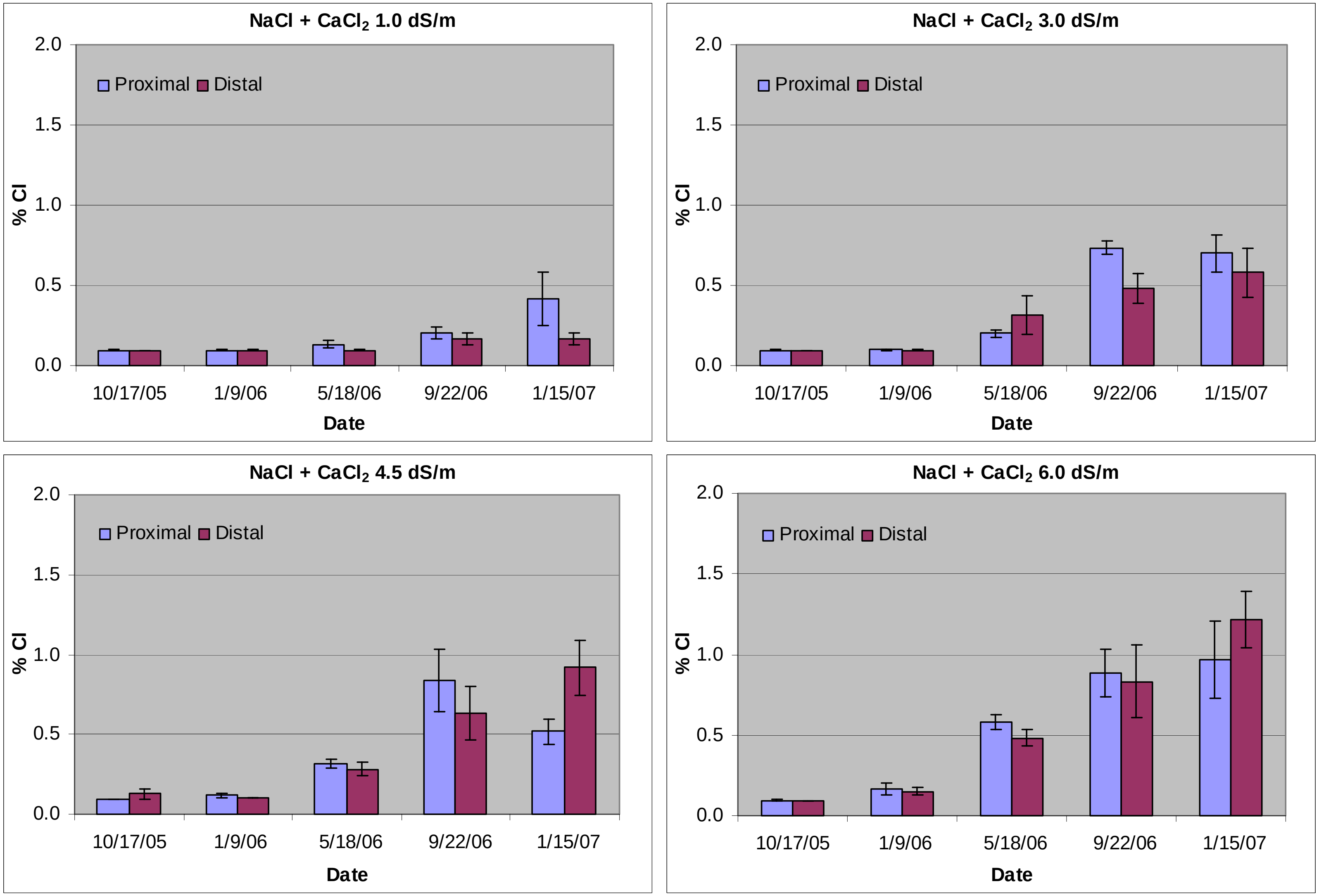

Figure 30. Leaf tissue mean % Cl by section for the NaCl + $CaCl_2$ treatments across five sampling dates. Error bars indicate ± 1 SE.

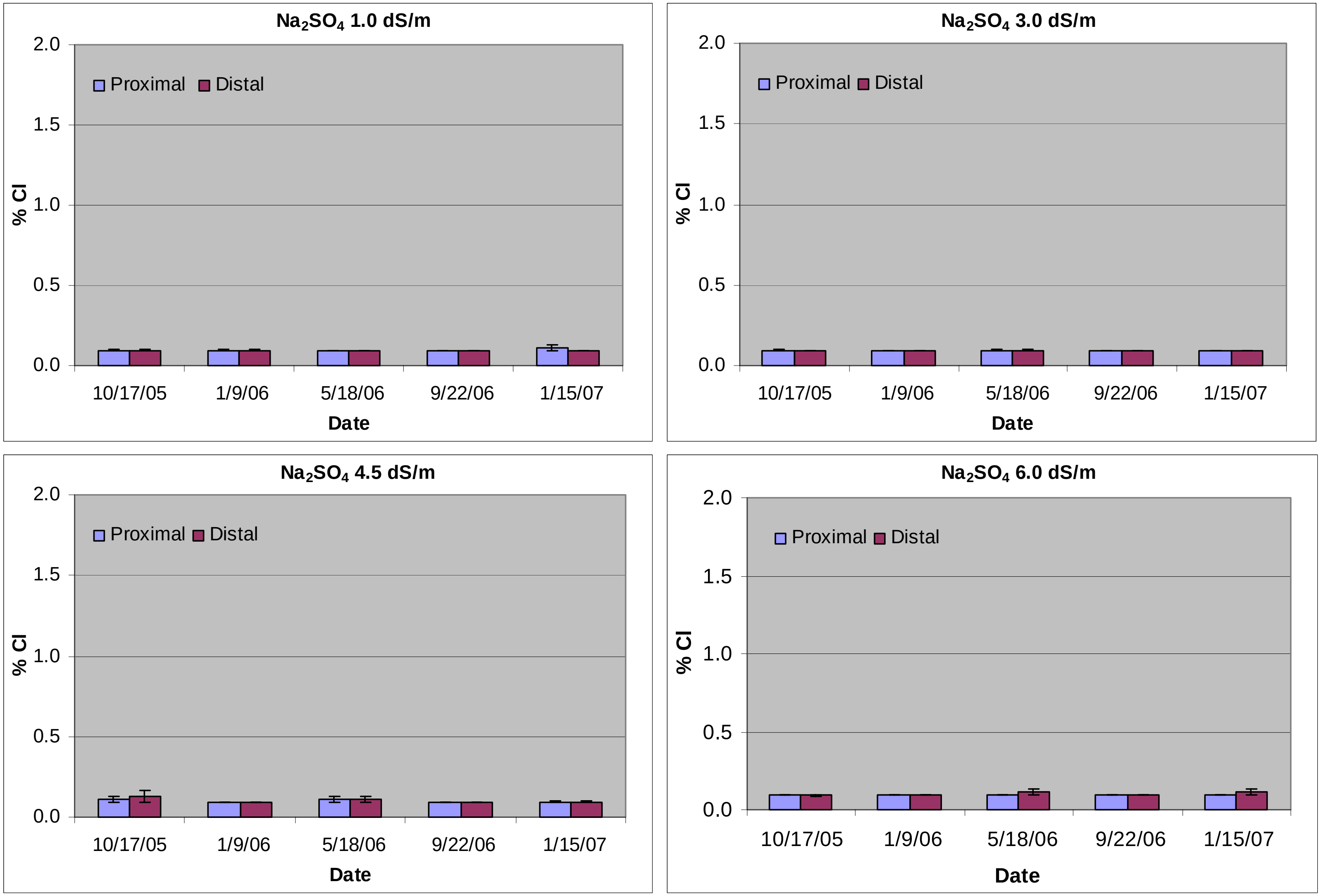

Figure 31. Leaf tissue mean % Cl by section for the Na_2SO_4 treatments across five sampling dates. Error bars indicate ± 1 SE.

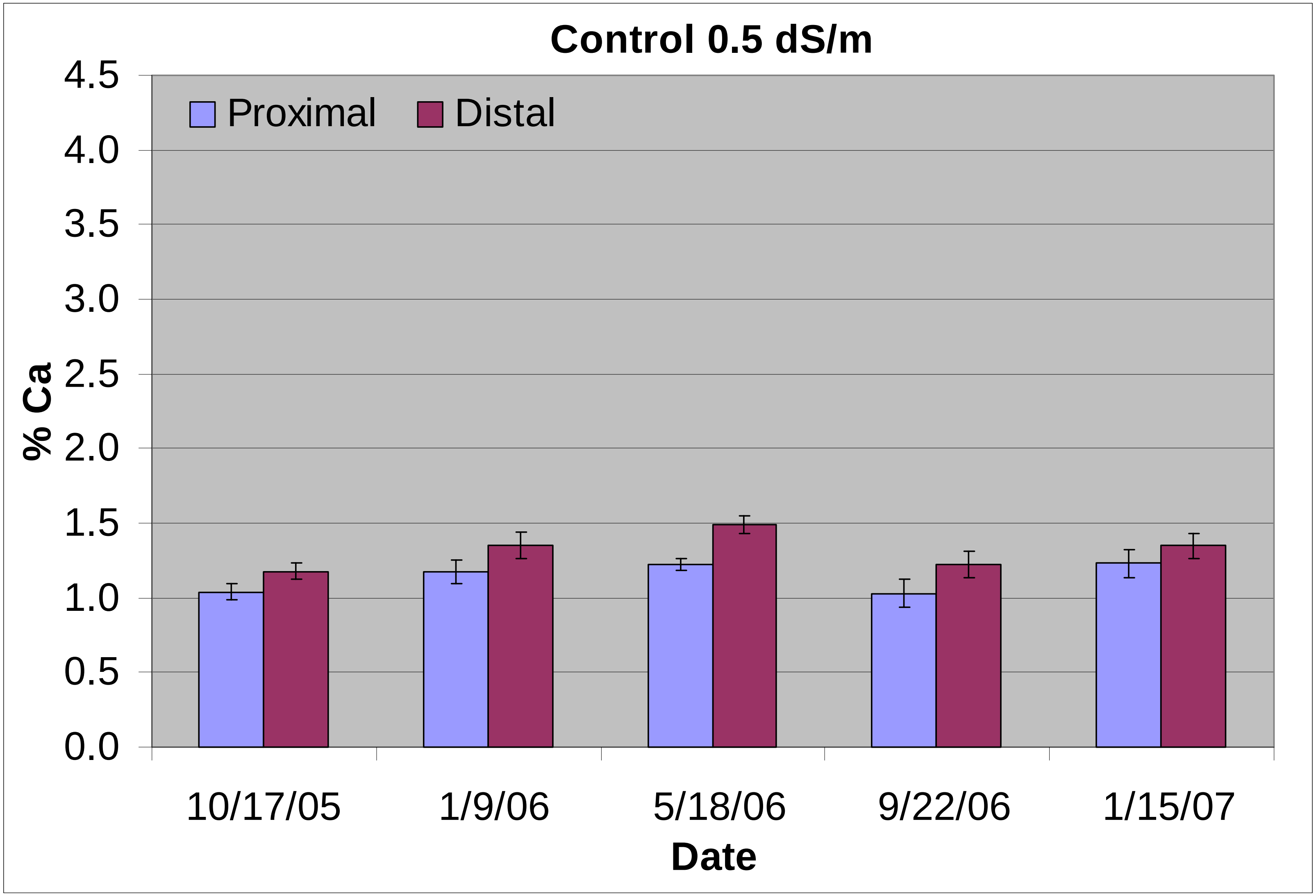

Figure 32. Leaf tissue mean % Ca by section for the control treatment across five sampling dates. Error bars indicate ± 1 SE.

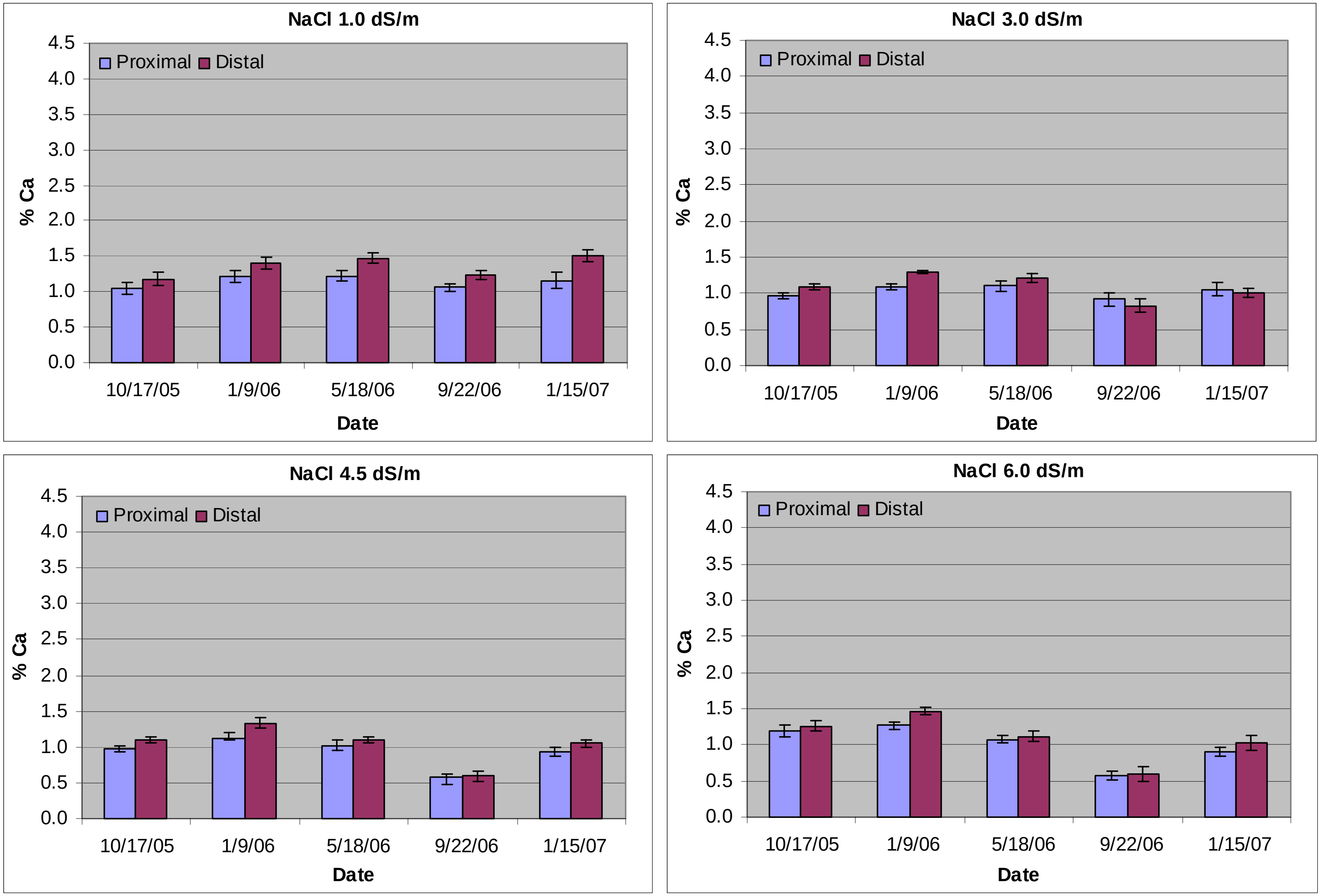

Figure 33. Leaf tissue mean % Ca by section for the NaCl treatments across five sampling dates. Error bars indicate ± 1 SE.

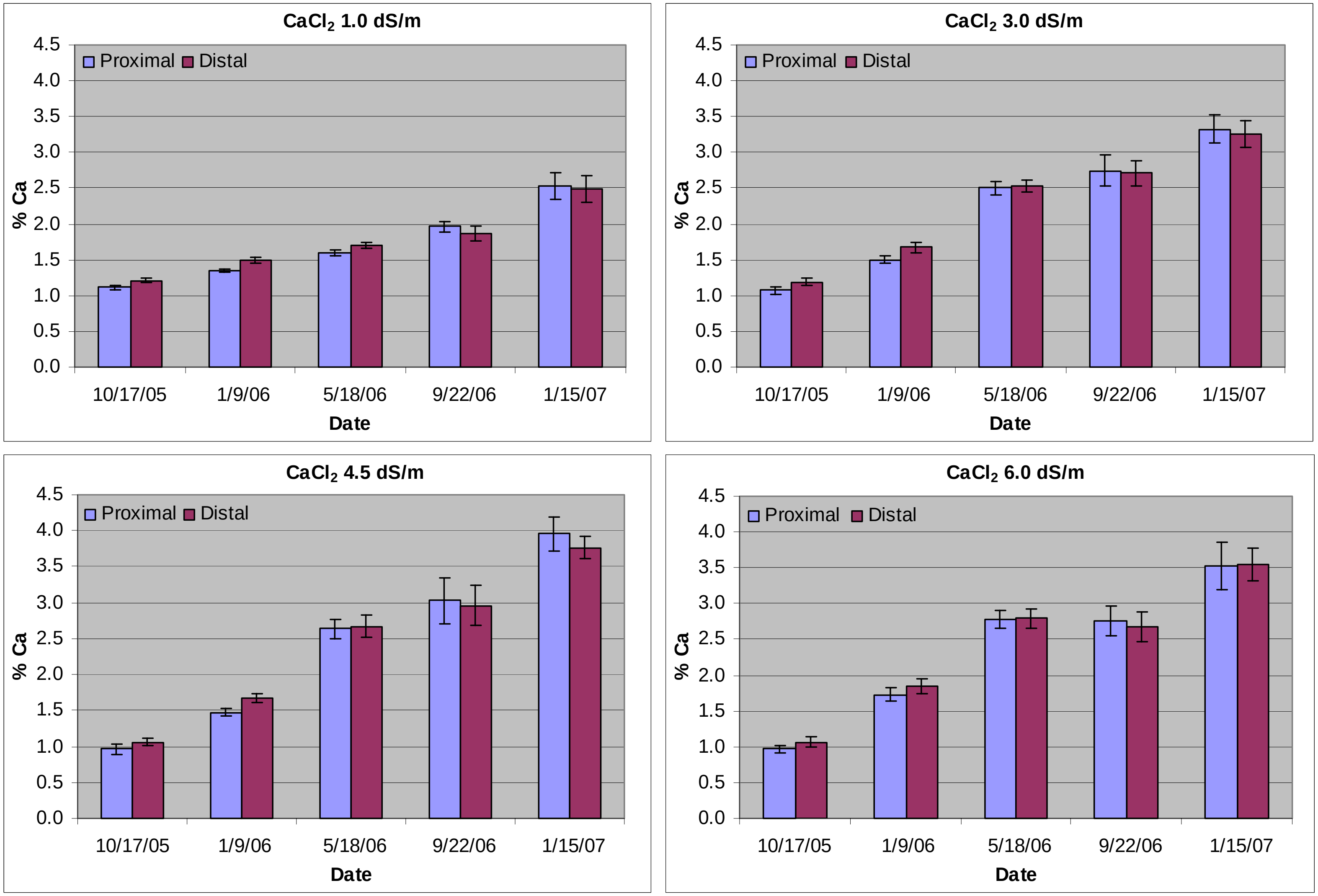

Figure 34. Leaf tissue mean % Ca by section for the $CaCl_2$ treatments across five sampling dates. Error bars indicate ± 1 SE.

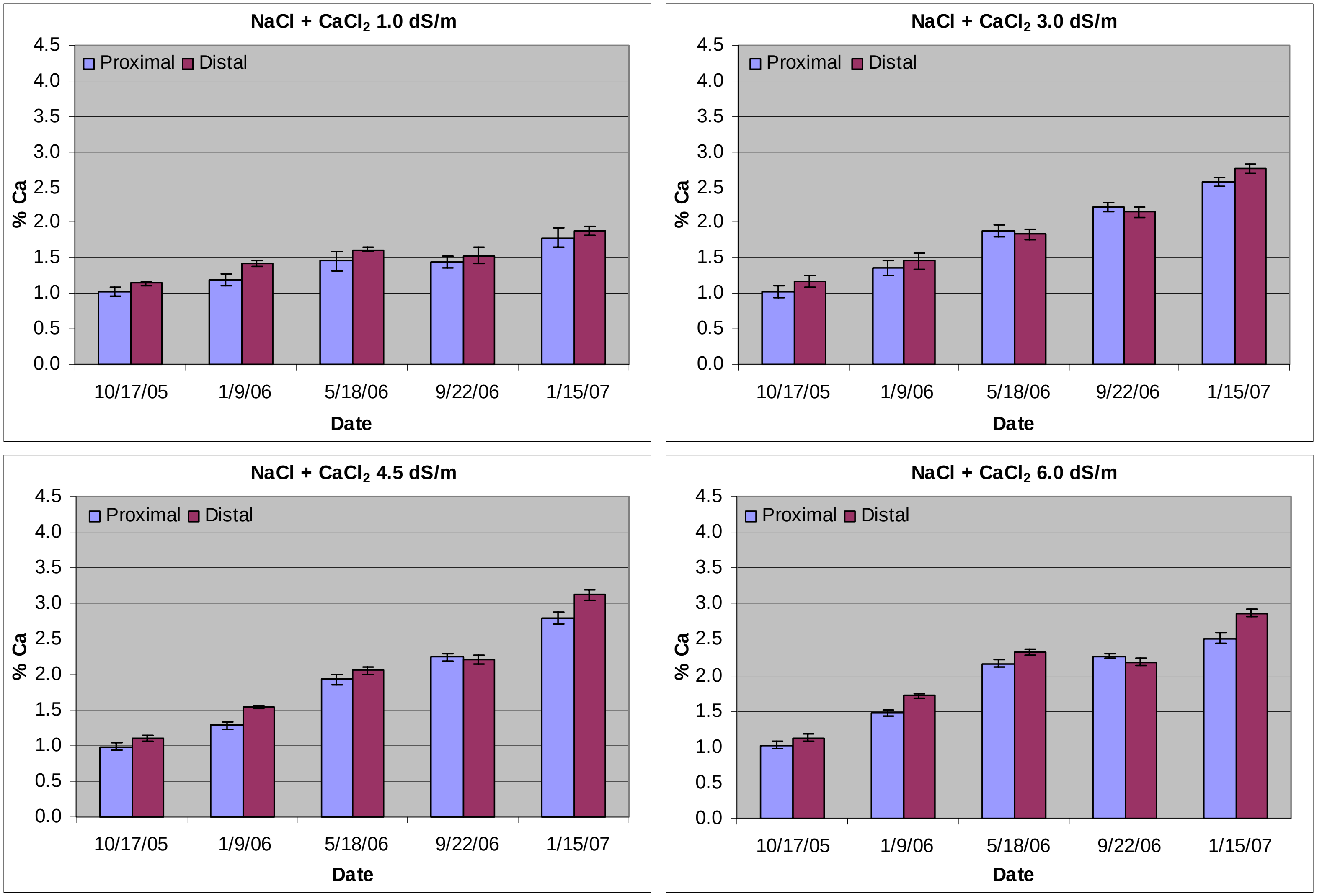

Figure 35. Leaf tissue mean % Ca by section for the NaCl + $CaCl_2$ treatments across five sampling dates. Error bars indicate ± 1 SE.

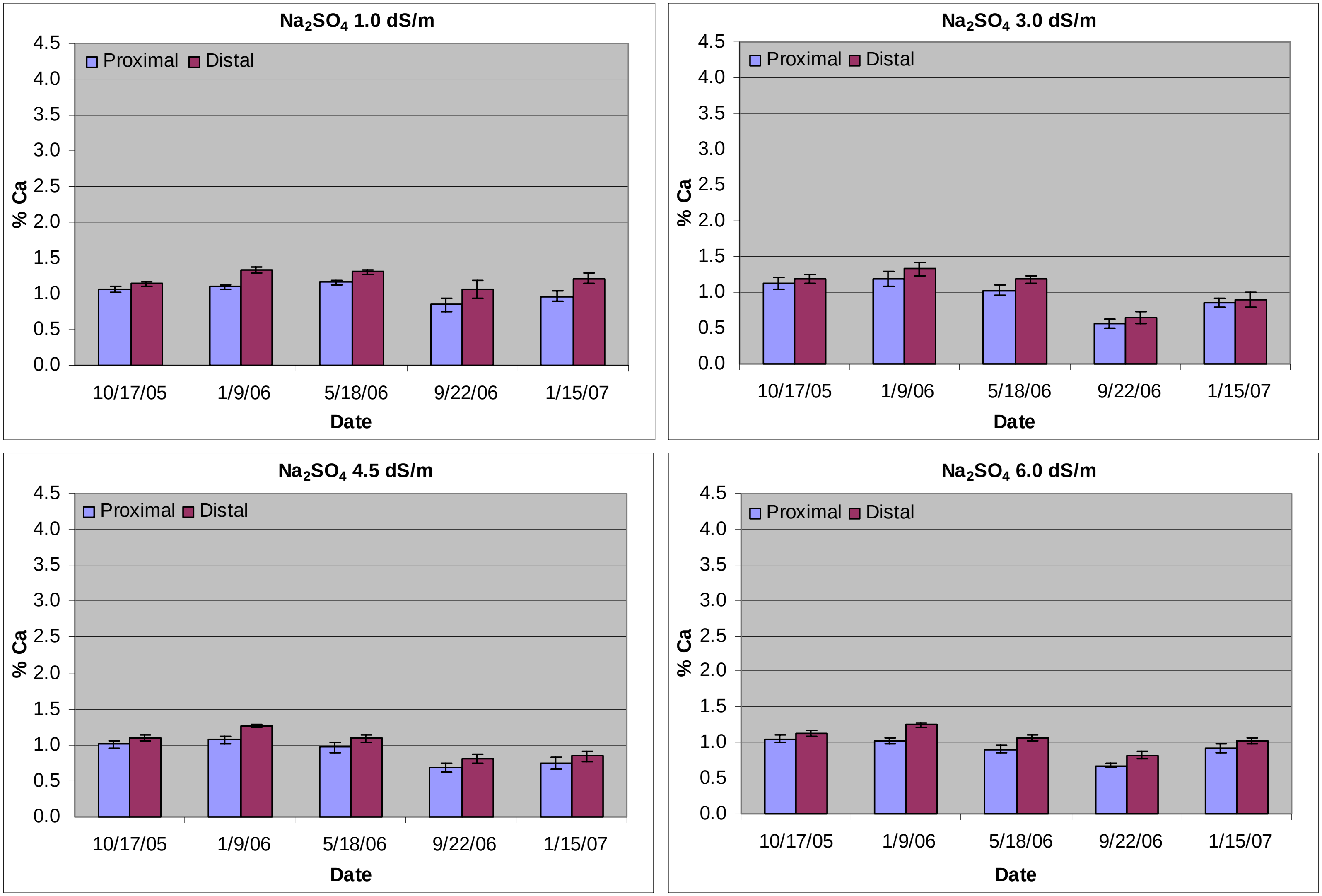

Figure 36. Leaf tissue mean % Ca by section for the Na_2SO_4 treatments across five sampling dates. Error bars indicate ± 1 SE.

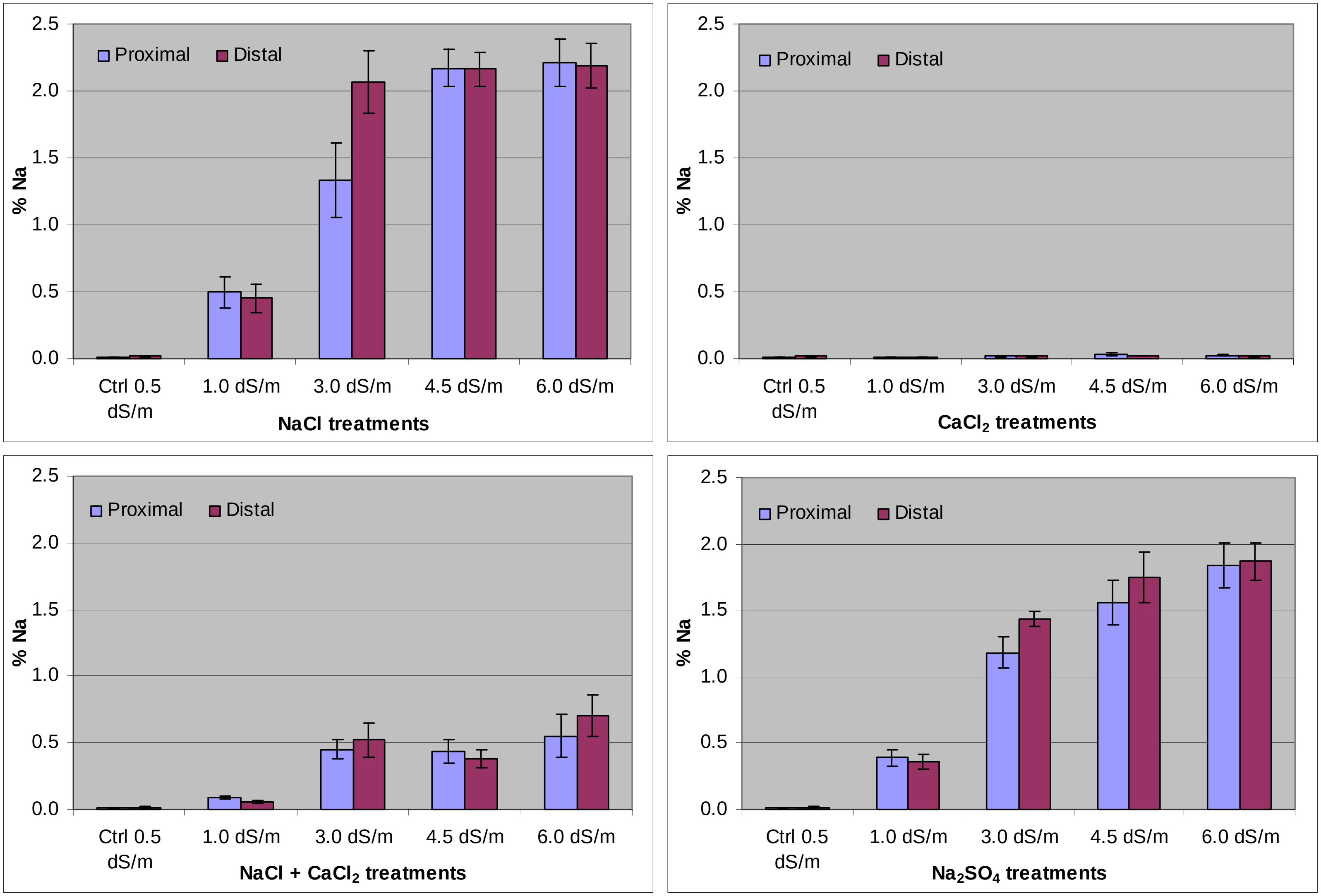

Figure 37. Leaf tissue mean % Na by section for all treatments on 1/15/07. Error bars indicate ± 1 SE.

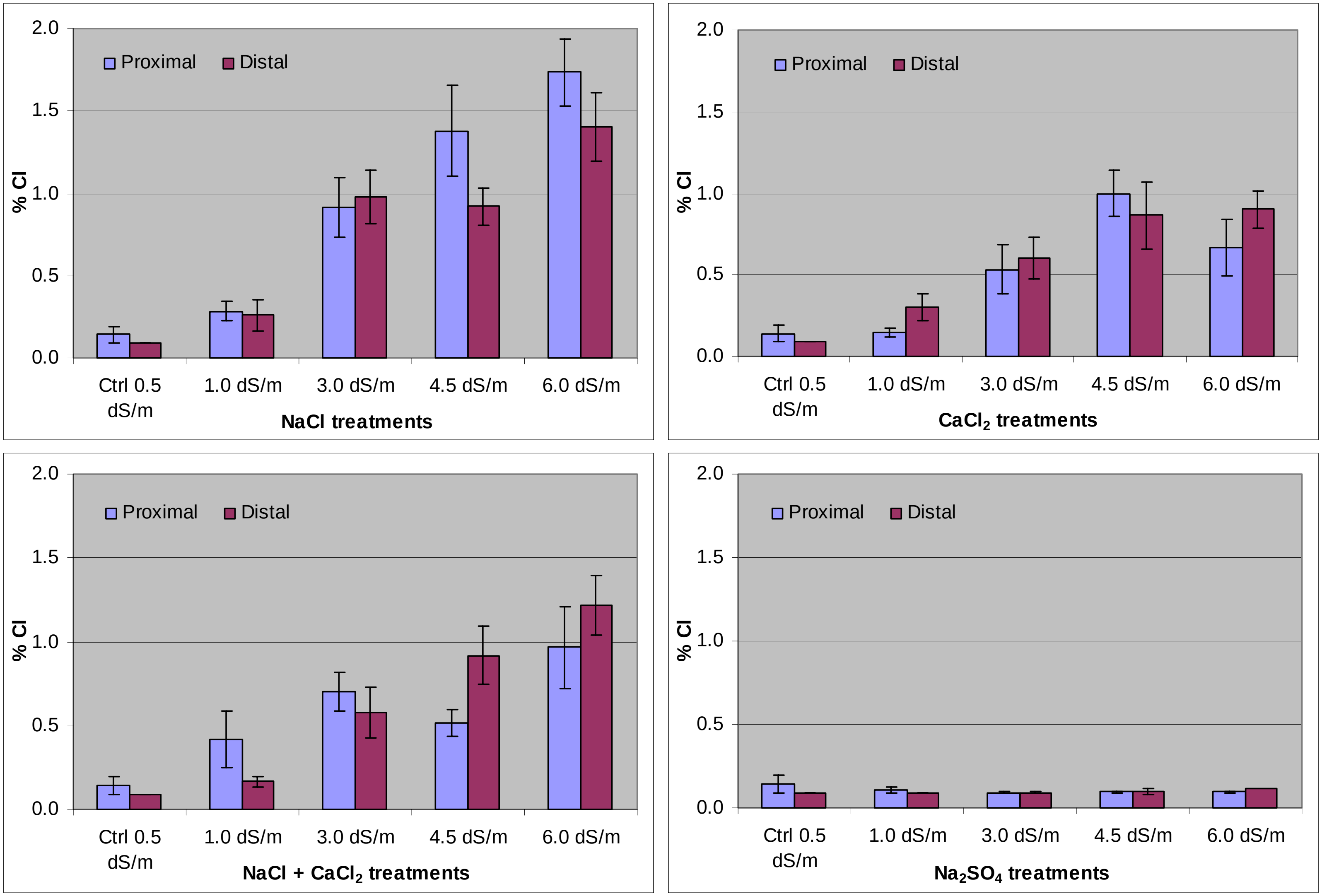

Figure 38. Leaf tissue mean % Cl by section for all treatments on 1/15/07. Error bars indicate ± 1 SE.

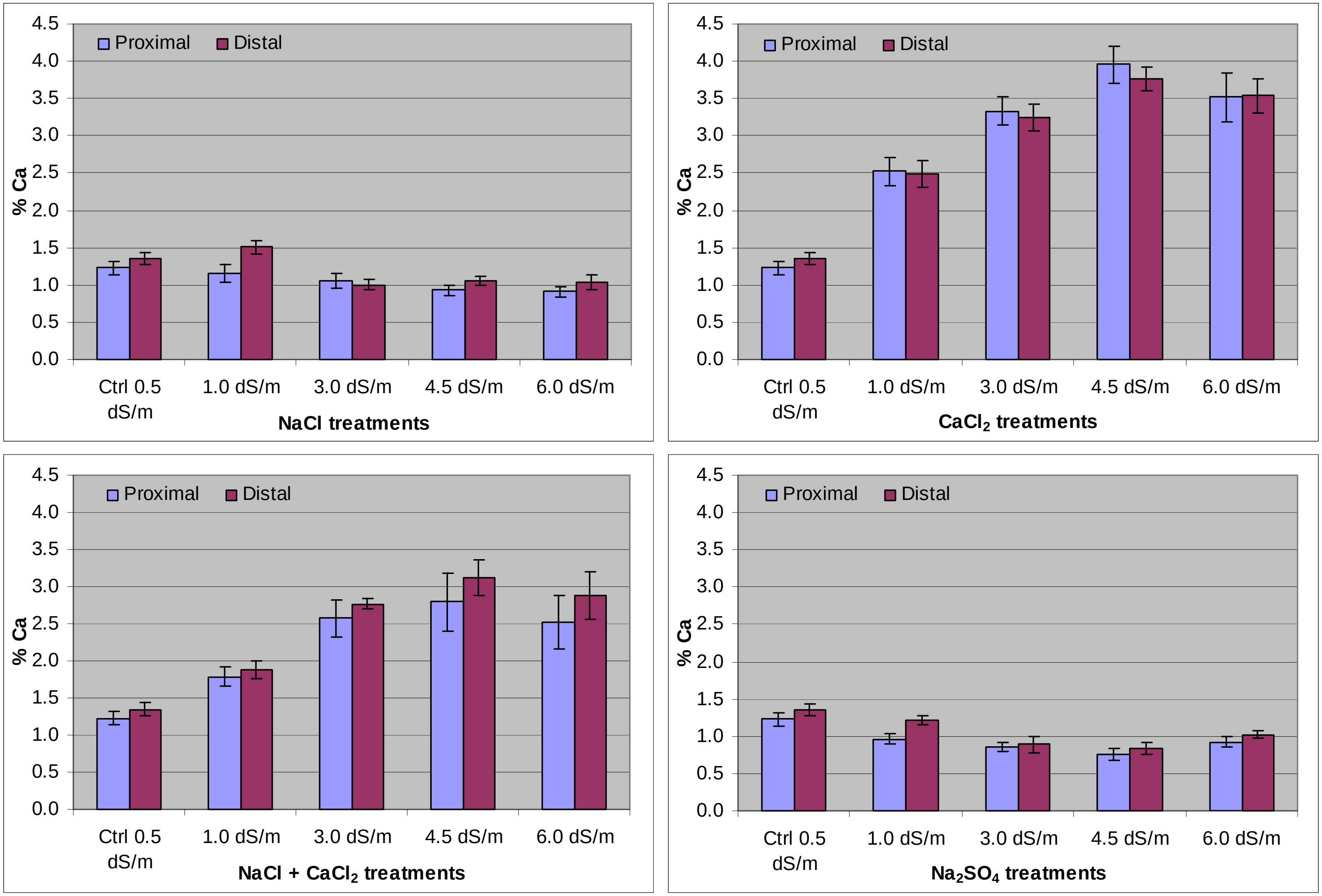

Figure 39. Leaf tissue mean % Ca by section for all treatments on 1/15/07. Error bars indicate ± 1 SE.

Figure 40. Control 0.5 dS/m treatment secondary branches on 1/10/07. All replicates (1-1 to 1-9) are represented and ordered left to right, top to bottom.

Figure 41. NaCl 1.0 dS/m secondary branches on 1/10/07. All replicates (2-1 to 2-6) are represented and ordered left to right, top to bottom.

Figure 42. NaCl 3.0 dS/m secondary branches on 1/10/07. All replicates (3-1 to 3-6) are represented and ordered left to right, top to bottom.

Figure 43. NaCl 4.5 dS/m secondary branches on 1/10/07. All replicates (4-1 to 4-6) are represented and ordered left to right, top to bottom.

Figure 44. NaCl 6.0 dS/m secondary branches on 1/10/07. All replicates (5-1 to 5-6) are represented and ordered left to right, top to bottom.

Figure 45. $CaCl_2$ 1.0 dS/m secondary branches on 1/10/07. All replicates (6-1 to 6-6) are represented and ordered left to right, top to bottom.

Figure 46. $CaCl_2$ 3.0 dS/m secondary branches on 1/10/07. All replicates (7-1 to 7-6) are represented and ordered left to right, top to bottom.

Figure 47. $CaCl_2$ 4.5 dS/m secondary branches on 1/10/07. All replicates (8-1 to 8-6) are represented and ordered left to right, top to bottom.

Figure 48. $CaCl_2$ 6.0 dS/m secondary branches on 1/10/07. All replicates (9-1 to 9-6) are represented and ordered left to right, top to bottom.

Figure 49. NaCl + $CaCl_2$ 1.0 dS/m secondary branches on 1/10/07. All replicates (10-1 to 10-6) are represented and ordered left to right, top to bottom.

Figure 50. NaCl + $CaCl_2$ 3.0 dS/m secondary branches on 1/10/07. All replicates (11-1 to 11-6) are represented and ordered left to right, top to bottom.

Figure 51. NaCl + $CaCl_2$ 4.5 dS/m secondary branches on 1/10/07. All replicates (12-1 to 12-6) are represented and ordered left to right, top to bottom.

Figure 52. NaCl + $CaCl_2$ 6.0 dS/m secondary branches on 1/10/07. All replicates (13-1 to 13-6) are represented and ordered left to right, top to bottom.

Figure 53. Na_2SO_4 1.0 dS/m secondary branches on 1/10/07. All replicates (14-1 to 14-6) are represented and ordered left to right, top to bottom.

Figure 54. Na_2SO_4 3.0 dS/m secondary branches on 1/10/07. All replicates (15-1 to 15-6) are represented and ordered left to right, top to bottom.

Figure 55. Na_2SO_4 4.5 dS/m secondary branches on 1/10/07. All replicates (16-1 to 16-6) are represented and ordered left to right, top to bottom.

Figure 561. Na_2SO_4 6.0 dS/m secondary branches on 1/10/07. All replicates (17-1 to 17-6) are represented and ordered left to right, top to bottom.

Appendix 1. Mean final trunk diameter and tree height.

Treatment	Mean Trunk Diameter (mm) ± 1 SE 1/3/2007	Mean Tree Height (cm) ± 1 SE 1/8/2007
Control 0.5 dS/m	49.97 ± 1.11	254.25 ± 22.91
NaCl 1.0 dS/m	49.94 ± 2.42	230.25 ± 16.52
NaCl 3.0 dS/m	38.88 ± 1.63	173.75 ± 14.24
NaCl 4.5 dS/m	37.49 ± 1.58	187.83 ± 15.66
NaCl 6.0 dS/m	29.82 ± 2.02	158.42 ± 14.73
$CaCl_2$ 1.0 dS/m	46.37 ± 1.43	237.58 ± 25.24
$CaCl_2$ 3.0 dS/m	44.68 ± 1.51	234.58 ± 18.94
$CaCl_2$ 4.5 dS/m	37.68 ± 1.35	209.50 ± 12.72
$CaCl_2$ 6.0 dS/m	32.79 ± 1.18	176.25 ± 9.88
NaCl + $CaCl_2$ 1.0 dS/m	53.39 ± 2.40	231.17 ± 33.74
NaCl + $CaCl_2$ 3.0 dS/m	42.26 ± 2.11	191.25 ± 24.71
NaCl + $CaCl_2$ 4.5 dS/m	39.24 ± 3.42	172.00 ± 13.54
NaCl + $CaCl_2$ 6.0 dS/m	34.34 ± 1.12	190.00 ± 15.77
Na_2SO_4 1.0 dS/m	49.06 ± 1.69	253.08 ± 31.69
Na_2SO_4 3.0 dS/m	40.91 ± 1.75	216.83 ± 16.94
Na_2SO_4 4.5 dS/m	32.37 ± 2.38	174.25 ± 12.59
Na_2SO_4 6.0 dS/m	30.64 ± 0.70	162.67 ± 11.44

Appendix 2. Mean Leaf % Na by date, treatment, and section. Error values indicate ± 1 SE.

Treatment	Section	10/17/05	1/9/06	5/18/06	9/22/06	1/15/07
Ctrl 0.5 dS/m	P	0.17 ± 0.03	0.14 ± 0.02	0.09 ± 0.02	0.13 ± 0.11	0.01 ± 0.00
	D	0.18 ± 0.03	0.15 ± 0.02	0.08 ± 0.02	0.02 ± 0.00	0.02 ± 0.00
NaCl 1.0 dS/m	P	0.15 ± 0.02	0.17 ± 0.02	0.18 ± 0.03	0.37 ± 0.06	0.50 ± 0.12
	D	0.14 ± 0.03	0.15 ± 0.03	0.21 ± 0.04	0.39 ± 0.07	0.45 ± 0.10
NaCl 3.0 dS/m	P	0.16 ± 0.05	0.32 ± 0.03	0.76 ± 0.07	1.22 ± 0.11	1.34 ± 0.28
	D	0.17 ± 0.05	0.38 ± 0.04	0.88 ± 0.16	1.46 ± 0.09	2.07 ± 0.23
NaCl 4.5 dS/m	P	0.15 ± 0.02	0.36 ± 0.04	0.99 ± 0.07	2.07 ± 0.10	2.17 ± 0.14
	D	0.14 ± 0.02	0.43 ± 0.07	1.37 ± 0.12	2.08 ± 0.12	2.17 ± 0.13
NaCl 6.0 dS/m	P	0.15 ± 0.01	0.47 ± 0.03	1.34 ± 0.07	2.74 ± 0.32	2.21 ± 0.18
	D	0.18 ± 0.02	0.68 ± 0.06	2.07 ± 0.15	2.61 ± 0.34	2.19 ± 0.17
$CaCl_2$ 1.0 dS/m	P	0.18 ± 0.04	0.17 ± 0.05	0.07 ± 0.02	0.01 ± 0.00	0.01 ± 0.00
	D	0.19 ± 0.05	0.17 ± 0.05	0.08 ± 0.03	0.01 ± 0.00	0.01 ± 0.00
$CaCl_2$ 3.0 dS/m	P	0.14 ± 0.04	0.13 ± 0.03	0.07 ± 0.03	0.01 ± 0.00	0.02 ± 0.01
	D	0.17 ± 0.05	0.14 ± 0.03	0.08 ± 0.03	0.01 ± 0.00	0.02 ± 0.01
$CaCl_2$ 4.5 dS/m	P	0.15 ± 0.03	0.15 ± 0.03	0.08 ± 0.03	0.02 ± 0.00	0.04 ± 0.01
	D	0.15 ± 0.03	0.15 ± 0.03	0.07 ± 0.03	0.01 ± 0.00	0.02 ± 0.00
$CaCl_2$ 6.0 dS/m	P	0.13 ± 0.02	0.13 ± 0.02	0.05 ± 0.01	0.01 ± 0.00	0.03 ± 0.01
	D	0.12 ± 0.02	0.11 ± 0.02	0.04 ± 0.01	0.01 ± 0.00	0.02 ± 0.00
NaCl + $CaCl_2$ 1.0 dS/m	P	0.16 ± 0.02	0.15 ± 0.03	0.10 ± 0.03	0.12 ± 0.02	0.09 ± 0.01
	D	0.15 ± 0.03	0.14 ± 0.04	0.08 ± 0.02	0.07 ± 0.02	0.06 ± 0.01
NaCl + $CaCl_2$ 3.0 dS/m	P	0.14 ± 0.02	0.17 ± 0.03	0.18 ± 0.02	0.43 ± 0.08	0.45 ± 0.07
	D	0.15 ± 0.03	0.18 ± 0.04	0.18 ± 0.04	0.42 ± 0.10	0.52 ± 0.13
NaCl + $CaCl_2$ 4.5 dS/m	P	0.15 ± 0.02	0.22 ± 0.02	0.24 ± 0.02	0.41 ± 0.06	0.44 ± 0.09
	D	0.15 ± 0.02	0.25 ± 0.03	0.27 ± 0.05	0.35 ± 0.05	0.38 ± 0.07
NaCl + $CaCl_2$ 6.0 dS/m	P	0.15 ± 0.02	0.22 ± 0.03	0.33 ± 0.04	0.53 ± 0.07	0.55 ± 0.16
	D	0.15 ± 0.02	0.27 ± 0.03	0.44 ± 0.05	0.50 ± 0.08	0.70 ± 0.16
Na_2SO_4 1.0 dS/m	P	0.13 ± 0.02	0.15 ± 0.02	0.20 ± 0.03	0.37 ± 0.07	0.39 ± 0.06
	D	0.14 ± 0.03	0.15 ± 0.02	0.24 ± 0.06	0.37 ± 0.06	0.36 ± 0.06
Na_2SO_4 3.0 dS/m	P	0.13 ± 0.02	0.26 ± 0.02	0.58 ± 0.05	1.07 ± 0.12	1.18 ± 0.12
	D	0.13 ± 0.02	0.32 ± 0.04	0.72 ± 0.07	1.30 ± 0.16	1.43 ± 0.06
Na_2SO_4 4.5 dS/m	P	0.12 ± 0.01	0.27 ± 0.04	0.82 ± 0.04	1.18 ± 0.05	1.56 ± 0.17
	D	0.12 ± 0.01	0.29 ± 0.06	1.03 ± 0.07	1.32 ± 0.08	1.75 ± 0.19
Na_2SO_4 6.0 dS/m	P	0.17 ± 0.03	0.39 ± 0.03	1.11 ± 0.06	1.55 ± 0.07	1.84 ± 0.17
	D	0.16 ± 0.03	0.44 ± 0.03	1.34 ± 0.08	1.52 ± 0.07	1.87 ± 0.14

Appendix 3. Mean Leaf % Cl by date, treatment, and section. Error values indicate ± 1 SE.

Treatment	Section	10/17/05	1/9/06	5/18/06	9/22/06	1/15/07
Ctrl 0.5 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.09 ± 0.00	0.14 ± 0.05
	D	0.09 ± 0.00	0.10 ± 0.00	0.12 ± 0.02	0.11 ± 0.02	0.09 ± 0.00
NaCl 1.0 dS/m	P	0.09 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.30 ± 0.07	0.28 ± 0.06
	D	0.09 ± 0.00	0.10 ± 0.00	0.11 ± 0.02	0.22 ± 0.05	0.26 ± 0.09
NaCl 3.0 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.25 ± 0.02	0.77 ± 0.04	0.92 ± 0.18
	D	0.10 ± 0.00	0.10 ± 0.00	0.15 ± 0.02	0.80 ± 0.12	0.98 ± 0.16
NaCl 4.5 dS/m	P	0.09 ± 0.00	0.10 ± 0.00	0.43 ± 0.02	0.87 ± 0.11	1.38 ± 0.27
	D	0.09 ± 0.00	0.10 ± 0.00	0.35 ± 0.02	0.45 ± 0.07	0.92 ± 0.12
NaCl 6.0 dS/m	P	0.09 ± 0.00	0.10 ± 0.00	0.98 ± 0.37	1.35 ± 0.16	1.73 ± 0.20
	D	0.09 ± 0.00	0.10 ± 0.00	1.02 ± 0.50	1.28 ± 0.35	1.40 ± 0.21
$CaCl_2$ 1.0 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.12 ± 0.02	0.17 ± 0.02	0.15 ± 0.02
	D	0.09 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.13 ± 0.02	0.30 ± 0.08
$CaCl_2$ 3.0 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.20 ± 0.04	0.65 ± 0.13	0.53 ± 0.15
	D	0.09 ± 0.00	0.10 ± 0.00	0.17 ± 0.03	0.43 ± 0.07	0.60 ± 0.13
$CaCl_2$ 4.5 dS/m	P	0.09 ± 0.00	0.10 ± 0.00	0.33 ± 0.07	0.48 ± 0.05	1.00 ± 0.14
	D	0.09 ± 0.00	0.10 ± 0.00	0.28 ± 0.02	0.42 ± 0.07	0.87 ± 0.21
$CaCl_2$ 6.0 dS/m	P	0.10 ± 0.00	0.12 ± 0.02	0.45 ± 0.02	0.67 ± 0.08	0.67 ± 0.17
	D	0.09 ± 0.00	0.12 ± 0.02	0.42 ± 0.03	0.48 ± 0.07	0.90 ± 0.11
NaCl + $CaCl_2$ 1.0 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.13 ± 0.02	0.20 ± 0.04	0.42 ± 0.17
	D	0.09 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.17 ± 0.03	0.17 ± 0.03
NaCl + $CaCl_2$ 3.0 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.20 ± 0.03	0.73 ± 0.04	0.70 ± 0.12
	D	0.09 ± 0.00	0.10 ± 0.00	0.32 ± 0.12	0.48 ± 0.09	0.58 ± 0.15
NaCl + $CaCl_2$ 4.5 dS/m	P	0.10 ± 0.00	0.12 ± 0.02	0.32 ± 0.03	0.83 ± 0.20	0.52 ± 0.08
	D	0.13 ± 0.03	0.10 ± 0.00	0.28 ± 0.04	0.63 ± 0.17	0.92 ± 0.17
NaCl + $CaCl_2$ 6.0 dS/m	P	0.10 ± 0.00	0.17 ± 0.03	0.58 ± 0.05	0.88 ± 0.14	0.97 ± 0.24
	D	0.09 ± 0.00	0.15 ± 0.02	0.48 ± 0.05	0.83 ± 0.22	1.22 ± 0.18
Na_2SO_4 1.0 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.09 ± 0.00	0.09 ± 0.00	0.11 ± 0.02
	D	0.10 ± 0.00	0.10 ± 0.00	0.09 ± 0.00	0.09 ± 0.00	0.09 ± 0.00
Na_2SO_4 3.0 dS/m	P	0.10 ± 0.00	0.09 ± 0.00	0.10 ± 0.00	0.09 ± 0.00	0.09 ± 0.00
	D	0.09 ± 0.00	0.09 ± 0.00	0.10 ± 0.00	0.09 ± 0.00	0.09 ± 0.00
Na_2SO_4 4.5 dS/m	P	0.11 ± 0.02	0.09 ± 0.00	0.11 ± 0.02	0.09 ± 0.00	0.10 ± 0.00
	D	0.13 ± 0.03	0.09 ± 0.00	0.11 ± 0.02	0.09 ± 0.00	0.10 ± 0.00
Na_2SO_4 6.0 dS/m	P	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00
	D	0.09 ± 0.00	0.10 ± 0.00	0.11 ± 0.02	0.09 ± 0.00	0.11 ± 0.02

Appendix 4. Mean Leaf % Ca by date, treatment, and section. Error values indicate ± 1 SE.

Treatment	Section	10/17/05	1/9/06	5/18/06	9/22/06	1/15/07
Ctrl 0.5 dS/m	P	1.04 ± 0.05	1.17 ± 0.08	1.22 ± 0.04	1.03 ± 0.09	1.23 ± 0.09
	D	1.18 ± 0.06	1.36 ± 0.09	1.49 ± 0.06	1.22 ± 0.09	1.35 ± 0.08
NaCl 1.0 dS/m	P	1.05 ± 0.08	1.21 ± 0.09	1.22 ± 0.08	1.07 ± 0.05	1.16 ± 0.12
	D	1.18 ± 0.09	1.41 ± 0.08	1.47 ± 0.07	1.23 ± 0.07	1.51 ± 0.08
NaCl 3.0 dS/m	P	0.97 ± 0.04	1.08 ± 0.04	1.10 ± 0.07	0.92 ± 0.10	1.06 ± 0.10
	D	1.09 ± 0.04	1.29 ± 0.02	1.21 ± 0.06	0.83 ± 0.09	1.00 ± 0.07
NaCl 4.5 dS/m	P	0.97 ± 0.04	1.12 ± 0.07	1.01 ± 0.08	0.57 ± 0.05	0.94 ± 0.07
	D	1.10 ± 0.05	1.33 ± 0.07	1.10 ± 0.04	0.59 ± 0.07	1.05 ± 0.06
NaCl 6.0 dS/m	P	1.18 ± 0.08	1.27 ± 0.05	1.08 ± 0.05	0.58 ± 0.06	0.91 ± 0.07
	D	1.26 ± 0.07	1.47 ± 0.05	1.12 ± 0.07	0.60 ± 0.10	1.03 ± 0.10
$CaCl_2$ 1.0 dS/m	P	1.12 ± 0.03	1.35 ± 0.03	1.60 ± 0.04	1.97 ± 0.07	2.53 ± 0.19
	D	1.21 ± 0.04	1.49 ± 0.04	1.70 ± 0.05	1.87 ± 0.11	2.49 ± 0.18
$CaCl_2$ 3.0 dS/m	P	1.07 ± 0.05	1.50 ± 0.05	2.50 ± 0.09	2.74 ± 0.22	3.33 ± 0.19
	D	1.19 ± 0.06	1.68 ± 0.07	2.53 ± 0.08	2.71 ± 0.17	3.26 ± 0.18
$CaCl_2$ 4.5 dS/m	P	0.96 ± 0.07	1.47 ± 0.05	2.64 ± 0.13	3.03 ± 0.32	3.95 ± 0.24
	D	1.06 ± 0.05	1.67 ± 0.06	2.67 ± 0.16	2.96 ± 0.27	3.76 ± 0.16
$CaCl_2$ 6.0 dS/m	P	0.97 ± 0.05	1.73 ± 0.09	2.78 ± 0.13	2.76 ± 0.22	3.52 ± 0.33
	D	1.07 ± 0.06	1.86 ± 0.10	2.79 ± 0.14	2.67 ± 0.21	3.54 ± 0.23
NaCl + $CaCl_2$ 1.0 dS/m	P	1.02 ± 0.07	1.20 ± 0.08	1.46 ± 0.14	1.44 ± 0.09	1.79 ± 0.14
	D	1.15 ± 0.04	1.43 ± 0.07	1.62 ± 0.06	1.54 ± 0.06	1.88 ± 0.11
NaCl + $CaCl_2$ 3.0 dS/m	P	1.03 ± 0.07	1.36 ± 0.07	1.89 ± 0.09	2.22 ± 0.06	2.57 ± 0.24
	D	1.18 ± 0.07	1.46 ± 0.06	1.84 ± 0.10	2.15 ± 0.06	2.77 ± 0.07
NaCl + $CaCl_2$ 4.5 dS/m	P	0.98 ± 0.06	1.29 ± 0.08	1.93 ± 0.07	2.24 ± 0.12	2.79 ± 0.39
	D	1.10 ± 0.06	1.54 ± 0.07	2.06 ± 0.05	2.21 ± 0.08	3.12 ± 0.24
NaCl + $CaCl_2$ 6.0 dS/m	P	1.02 ± 0.08	1.47 ± 0.06	2.16 ± 0.05	2.27 ± 0.23	2.52 ± 0.36
	D	1.13 ± 0.07	1.72 ± 0.06	2.32 ± 0.08	2.18 ± 0.22	2.87 ± 0.32
Na_2SO_4 1.0 dS/m	P	1.06 ± 0.04	1.10 ± 0.04	1.16 ± 0.04	0.85 ± 0.09	0.97 ± 0.08
	D	1.14 ± 0.03	1.33 ± 0.04	1.30 ± 0.04	1.06 ± 0.12	1.22 ± 0.07
Na_2SO_4 3.0 dS/m	P	1.13 ± 0.08	1.19 ± 0.11	1.03 ± 0.08	0.56 ± 0.07	0.86 ± 0.06
	D	1.19 ± 0.06	1.32 ± 0.09	1.18 ± 0.05	0.64 ± 0.08	0.89 ± 0.10
Na_2SO_4 4.5 dS/m	P	1.01 ± 0.05	1.08 ± 0.05	0.97 ± 0.07	0.69 ± 0.05	0.75 ± 0.08
	D	1.09 ± 0.05	1.26 ± 0.02	1.09 ± 0.05	0.81 ± 0.07	0.84 ± 0.08
Na_2SO_4 6.0 dS/m	P	1.06 ± 0.05	1.03 ± 0.04	0.91 ± 0.05	0.68 ± 0.03	0.92 ± 0.07
	D	1.13 ± 0.05	1.25 ± 0.03	1.08 ± 0.04	0.82 ± 0.05	1.02 ± 0.05

From: Nelda Matheny
To: Jim Inglis;
Subject: recycled water
Date: Friday, April 17, 2009 8:15:39 AM
Attachments: designing for recycled water handout.pdf

Hi Jim,
I'm only in the office for a few minutes, so I haven't had time to put much together for you. Attached is a short manuscript about some of the issues with using recycled water in landscapes.

As I mentioned on the phone, my experience with redwoods is that they are very sensitive to salts and usually begin to show toxicity symptoms within one to two years of its application. Redwoods must be irrigated frequently because they have no drought tolerance. Each irrigation adds salt, and over time the salts in the soil accumulate to damaging concentrations. I have observed mature redwoods significantly damaged after 3 years of irrigation with recycled water.

I do not think that is it possible to maintain healthy redwoods with recycled water containing high concentrations of sodium and chloride using conventional techniques and water-conserving irrigation schedules. It may be possible with adjustments to management practices such as leaching, abundant irrigation, and application of amendments to help leach salts. These modifications have yet to be tested in field applications.

As for coast live oak, it is quite tolerant of salt. Coast live oak can be maintained in a healthy condition when irrigated with recycled water. In general, drought tolerant species that require only infrequent irrigation are well suited for recycled water.

Feel free to share this information and my opinions with others.

Nelda

Nelda Matheny
HortScience, Inc.
2150 Rheem Dr., Suite A, Pleasanton CA
925 484 0211

University of California
Division of Agriculture and Natural Resources
http://anrcatalog.ucdavis.edu

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SOUTHWEST STATES & PACIFIC ISLANDS
Regional Water Program

Safe Application of Reclaimed Water Reuse in the Southwestern United States

LAOSHENG WU, University of California Cooperative Extension Water Management Specialist, UC Riverside; **WEIPING CHEN**, Research Associate, UC Center for Water Resources; **CHRISTINE FRENCH**, Program Analyst, UC Center for Water Resources; **ANDREW CHANG**, Director Emeritus, UC Center for Water Resources

INTRODUCTION

In the arid and semiarid southwestern United States, the land and the people thirst for more water. The reclamation era of the 1930s to 1960s saw the construction of infrastructure for storing and conveying water by the federal government that greatly aided the development of America's West. With the increase in available water, more land was put into production and more people moved west. As the population continues to grow, increased demands are being placed on water resources for urban, agricultural, and environmental needs.

The California Department of Water Resources (DWR) projects that the state's population will grow by 17 million people over the next 25 years, catapulting to 52 million by 2030 (DWR 2005). Urban water demands are expected to rise by 47 percent, yet agricultural and environmental needs are expected to hold steady. U.S. Census Bureau estimates show that populations in both Arizona and Nevada are expected to double by 2030 (from 2000 totals), adding an additional 7 million people to those two states. This will put further demands on the region's water resources.

The readily available sources of water in the Southwest have been exhausted. Costs of bringing additional water on line, if available, would be prohibitively expensive. While options for developing water supplies via traditional approaches are limited, municipal wastewater is readily available, as it is produced at the proximity of the demands, is reliable, and may be treated to meet required standards at a reasonable cost.

With the discharge requirements stipulated by the federal Clean Water Act (CWA, 1972), reclaimed wastewater has been steadily improving in quality and is increasingly being recognized as a potential source of water supply. Water pollution control efforts implemented around the world since the 1960s are producing large volumes of treated municipal wastewater effluent that are, for the most part, currently discharged to surface water bodies or to the oceans. Water reclamation, recycling, and reuse are now recognized worldwide as key components in the efficient management of water resources. Arizona, California, and Nevada have promulgated regulations and established programs that strongly encourage water reuse as a strategy for water resources conservation.

Water Reuse Opportunities

With advances in technology, wastewater may be treated to meet the most stringent quality requirements and can be used for any purposes desired. The potential uses for reclaimed water are indeed numerous and widely varied (fig. 1); however, reclaimed water has been used most commonly for nondirect consumption and non-body-contact purposes.

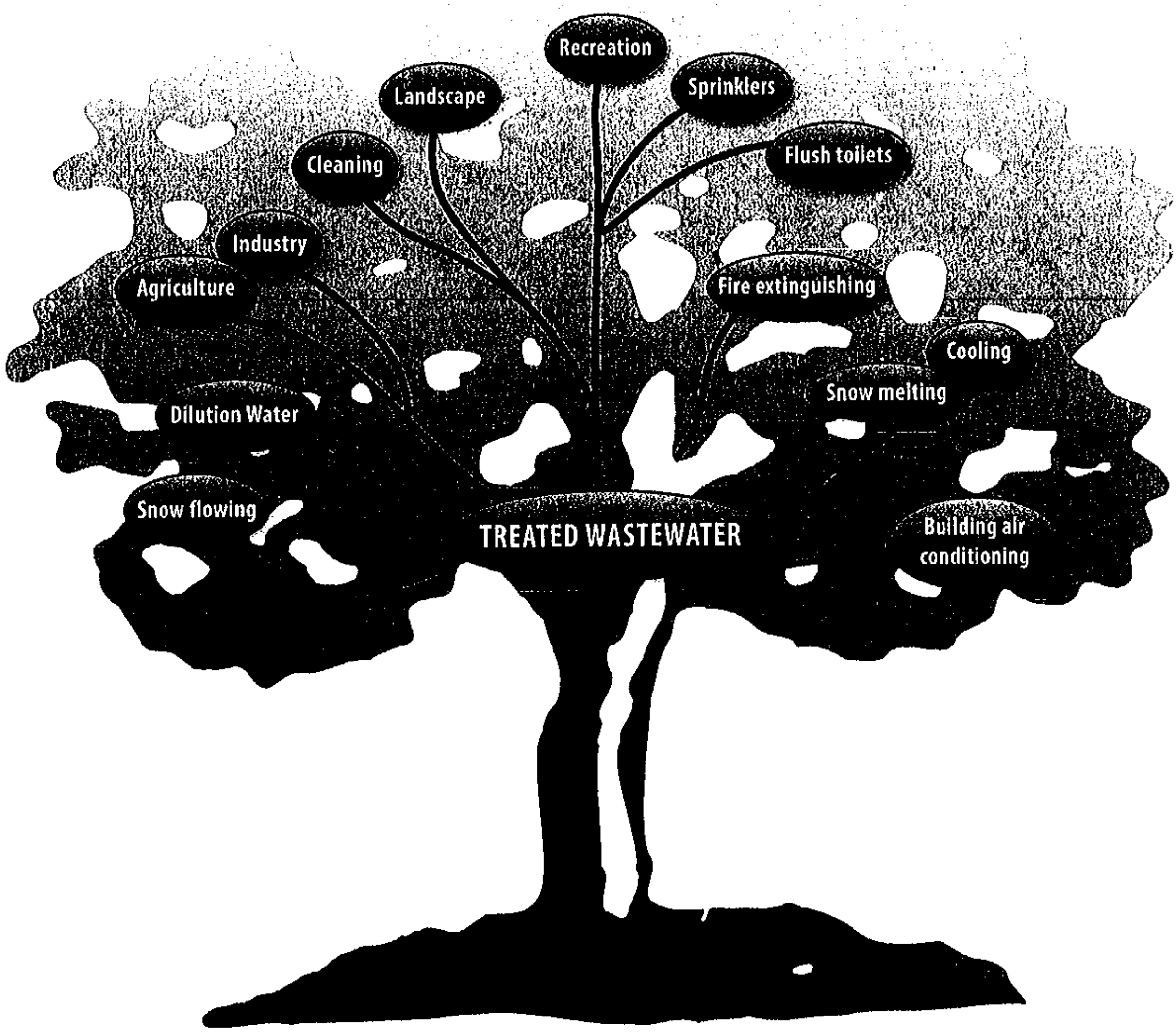

Figure 1. Wastewater reuse opportunities. *Source:* After MLIT 2001.

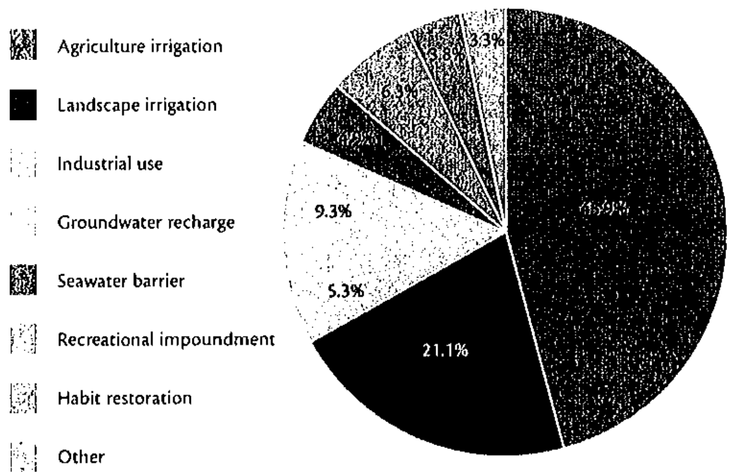

Figure 2. Wastewater reuse in California. *Source:* CSWRCB 2003.

Water reuse in the Southwest

Water recycling in California is an integral part of the water management plan, and over 500,000 acre-feet (AF) of reclaimed water is put to beneficial use annually (CSWRCB 2003). (For metric and English equivalents, see the table at the end of this publication.) The most common uses are for agricultural and landscape irrigation (fig. 2).

The Arizona Department of Water Resources has established five active management areas (AMAs) charged with management and conservation of groundwater resources as well as finding viable options to supplement current water supplies. While the AMAs cover only 13 percent of Arizona's land area, 80 percent of the population live within these areas. Each AMA is using reclaimed wastewater to meet their charge. In 2003, 244,000 acre-feet of reclaimed water was reported to be put to beneficial uses within the five AMAs; of that total, agricultural and landscape irrigation accounted for approximately 48 percent of the usage (29% agricultural irrigation, 28% industrial use, 24% groundwater recharge, 19% landscape irrigation) (for more detailed information, see ADWR 1999). Reclaimed water is also being used in areas outside the AMAs; however, that use has not yet been quantified.

In southern Nevada, reclaimed water is being used to control dust at landfills and at sand and gravel operations, as a coolant for power generation plants, and for irrigation of golf courses, highway landscaping, and parks. In 2004, agencies within the Southern Nevada Water Authority used approximately 24,000 acre-feet of reclaimed water for these purposes (SNWA 2006).

Objectives

The objectives of this publication are to provide up-to-date knowledge about

- federal and state regulations and guidelines on water reuse
- physical, chemical, and biological characteristics of reclaimed wastewaters
- the safe application of wastewater for landscape and agriculture

Federal and State Regulations and Guidelines on Wastewater Reuse

To ensure public health and safety, reclaimed waters are often subject to rigorous regulatory controls, including defined levels of treatment, set numerical limits for water quality, and qualitative control factors such as process reliability requirements. In the United States, regulations governing water reuse may be described as a tiered system that begins with requirements decreed by federal legislation and works its way down to local ordinances and codes.

No federal regulations directly govern water reuse practices in the United States. Water reuse regulations and guidelines have, however, been developed by 25 states including Arizona, California, and Nevada; an additional 16 states have guidelines or design standards, leaving only 9 states with no regulations or guidelines. Contents of the regulations and guidelines vary considerably from state to state. States such as Arizona, California, and Nevada have developed regulations or guidelines that strongly encourage reuse as a water conservation strategy. Their regulations or guidelines specify water quality requirements, treatment processes, or both, for the full spectrum of reuse applications. The objective of these regulations is to derive the maximum resource benefits of the reclaimed water while protecting the environment and public health.

Federal Jurisdiction

Although no formal statute at the federal level specifically covers the use of recycled water, the Clean Water Act provides the umbrella legislative mandate that covers all forms of effluent discharges from publicly owned treatment works (POTW, or wastewater treatment plants). The CWA requires industries that discharge wastewater into municipal sewers to comply with prescribed industrial pretreatment requirements, meet preset treatment performance standards, and obtain permits for discharging effluent. The two programs under the Clean Water Act that are most relevant to water treatment and reuse are the Industrial Wastewater Pretreatment Program and the National Pollutant Discharge Elimination System (NPDES) Program.

The Industrial Wastewater Pretreatment Program requires industrial dischargers to treat their discharge water to a level that will not cause disruption of the POTW's treatment system prior to discharging to the sanitary sewer system. The enactment of this program protects the efficiency of POTW treatment and enables reclaimed water to be used without undue water quality limitations.

The NPDES program (permit) sets limits on water quality constituents and is required for any discharges to the nation's waterways. All federally funded wastewater treatment for reuse projects must comply with provisions listed in the NPDES program. Forty-five states have been delegated the authority of issuing NPDES permits. These states or their agencies may elect to adopt the federally mandated requirements or impose more stringent pollutant discharge standards.

The authorized state agencies, such as the California State Water Resources Control Board (SWRCB) along with its Regional Water Quality Control Boards (RWQCB), the Arizona Department of Environmental Quality (ADEQ), and the Nevada Division of Environmental Protection Bureau of Water Pollution Control (BWPC) have the authority to issue or deny a permit based on information submitted by the permit applicant. Public input through hearings may be required prior to the regulator's adoption or denial of the permit application; issued permits must be renewed or reissued every 5 years.

State Water Reuse Regulations

Regulatory authority

States hold the primary responsibility for regulating water reuse in the United States. However, the jurisdiction of regulating water reuse may be contained within a single agency or may be divided among several agencies. In California, each of the nine RWQCBs is responsible for issuing effluent discharge permits either under the authorization of the NPDES program (discharge of treated effluent to a stream, river, or ocean) or the waste discharge requirements (discharge of treated effluent to land, such as reclaimed water for irrigation purposes). Rules and regulations for the end use of recycled water are established and enforced by each RWQCB, the California Department of Public Health (DPH) and the local city or county health department. These rules and regulations are typically contained in a permit from the regional board issued to the individual recycled water agency or producer (see California Code of Regulations Title 22, Chapter 3, Reclamation Criteria).

The Arizona Department of Environmental Quality requires water reuse projects to obtain the Reclaimed Water Individual Permit or Reclaimed Water General Permit (see Arizona Administrative Code, Title 18, Chapter 9, articles 6 and 7; and Chapter 11, article 3). An individual discharge permit is required for the reuse of industrial wastewater that contains a component of sewage or is used in processing any crop or substance that may be used as human or animal food. To encourage water reuse, nine general discharge permits that outline the requirements for different classes of reuse have been established. Permits are granted to operators who can demonstrate meeting the requirements specified in the general discharge permits. Among the 9 permits, 2 cover gray water (water from clothes washers, bathtubs, showers, and baths, not from kitchen sinks, dishwashers, or toilets); 1 covers the reclaimed water agent; 1 covers the reclaimed water blending facility; and 5 cover the end users based on the reclaimed water class. The processes for general discharge permits take less time to complete and require lower review fees than the individual discharge permit.

The Nevada Division of Environmental Protection (NDEP) must be contacted when water reuse is planned. NDEP will determine the appropriate discharge permit and assist the applicants in preparing the design submittal. Prior to granting the permit, NDEP conducts a comprehensive review of the plans for the reclaimed water use project that are prepared and certified by registered professional engineers in Nevada. To address issues related to secondary water rights, the Nevada Division of Water Resources (NDWR) must be consulted. Finally, the Nevada State Health Division (NSHD) should also be consulted to ensure that the plan is consistent with water supply protection requirements.

Reclaimed water quality and treatment requirements

Arizona, California, and Nevada have set standards for reclaimed water quality or have specified minimum treatment requirements that are dependent on the end uses of the water. When unrestricted public exposure is likely to take place during the course of reuse, reclaimed water must meet stringent quality standards and performance levels. When there is no public exposure, the quality standards and the treatment levels may be relaxed (table 1). Biochemical oxygen demand (BOD), total suspended solids (TSS), and total or fecal coliform counts are the most common water quality parameters for which the upper thresholds are imposed, with biological oxygen demand and total suspended solids serving as indicators for the adequacy and reliability of the treatment, and total or fecal coliform counts as an indicator of the extent of disinfection through the treatment process. Total or fecal coliform is considered in order to minimize the exposures to pathogenic organisms.

In addition to the use categories summarized in table 1, California has separate rules pertaining to groundwater recharge and industrial reuse of reclaimed wastewater. The required wastewater treatment processes are not specified; instead, DPH evaluates all relevant aspects of a proposed project, including treatment provided, effluent quality and quantity, nature of the spreading operation, soil characteristics, hydrogeology, residence time, and travel distance to point of withdrawal. Requirements for the project are then determined based on the evaluation findings.

No specific requirements exist in Arizona, California, or Nevada for reclaimed water used for environmental purposes of enhancing or maintaining aquatic ecosystem functions and services.

Table 1. Wastewater reuse criteria of Arizona, California, and Nevada

Use category	Parameter	Arizona	California	Nevada
unrestricted urban reuse; agricultural reuse: food crops; unrestricted recreational reuse	treatment level	secondary treatment, filtration, and disinfection	oxidized, coagulated, filtered, and disinfected	secondary treatment and disinfection
	BOD5 (mg/l)	NS	NS	30
	turbidity (NTU)	average 2; maximum 5	average 2; maximum 5	NS
	fecal coliform (MPN/100 ml)	average: not available; maximum 23	NS	average 2.2; maximum 23*; average 200; maximum 400†
	total coliform (MPN/100 ml)	NS	average 2.2; 30-day maximum 23	NS
restricted urban reuse; nonfood crop irrigation; restricted recreational reuse	treatment level	secondary treatment and disinfection	secondary, oxidized, and disinfected	secondary treatment and disinfection
	BOD5 (mg/l)	NS	NS	30
	fecal coliform (MPN/100 ml)	average 200; maximum 800	NS	average 23; maximum 240‡; average 200; maximum 400§
	total coliform (MPN/100 ml)	NS	average 23; 30-day maximum 240¶; average 2.2; 30-day maximum 23**	NS

Key: BOD = biological oxygen demand; MPN = most probable number; NS = not specified; NTU = nephelometric turbidity units.

Notes:

*Apply to unrestricted urban reuse and unrestricted recreational reuse.

†Apply to agricultural reuse—food crops.

‡Restricted urban and recreational reuses.

§Agricultural reuse—nonfood crops.

¶Apply to restricted urban reuse and agricultural reuse—nonfood crops.

**Restricted recreational reuse.

Site management practices

Water quality monitoring. The quality of reclaimed wastewater slated for reuse is routinely monitored on a quarterly, monthly, weekly, daily, or continuous basis depending on the constituents. For example, daily sampling for fecal coliform is required for unrestricted urban reuse in Arizona, while monthly sampling is sufficient for nonfood crop irrigation. The turbidity of the finished water is often continuously monitored in real time, as is required in California.

Treatment facility reliability. Treatment plants producing reclaimed water may be required to implement provisions to ensure reliability of processing. These provisions include alarms to warn of power failure, automatic standby power source, emergency storage, and redundancy or backup units. California's reclamation criteria (see California Administrative Code Title 22, Chapter 3, Articles 8 to 10) cover the design and operational considerations for alarms, power supply, emergency effluent storage and disposal, treatment processes, chemical supply, storage, and feed facilities. In general, operators may adopt different options to ensure the reliability of their process.

Physical, Chemical, and Biological Characteristics of Reclaimed Wastewaters

In the Western Hemisphere, municipal wastewater treatment has been practiced for over a century. Early attempts at reusing wastewater were plagued with pollution and public nuisances caused by hydraulic and pollutant overloading. Advances in treatment technologies enabled the production of treated wastewater effluents now suitable for a variety of uses. In this section, a brief description of the wastewater treatment processes and general principles of water purification and quality characteristics of source and finished waters will be reviewed in terms of water reuse potential.

Wastewater Treatment Processes

Municipal wastewater collection systems receive spent water and associated pollutants from discharges at service connections throughout a community. While the exact substances and their quantities are vague, all collected wastewaters contain impurities that may be categorized into the following general groups:

- biodegradable organic matter (BOM)
- pathogens and indicator organisms
- nutrients (nitrogen and phosphorus)
- potentially toxic substances
- dissolved minerals

To make the product water suitable for reuse or discharge, influent wastewater is routed through a series of unit processes through which impurities are removed. Treatment is divided into four general stages: preliminary, primary, secondary, and tertiary (or advanced). Depending on the desired characteristics of the target water and treatment objectives, unit processes can be selectively employed. Table 2 summarizes the goals and typical processes of each stage.

Preliminary treatment

Publicly owned treatment works (POTW) are designed and operated such that the processes in the preliminary stage prepare incoming wastewater for downstream treatment by measuring incoming flow and screening out oversized objects; separating sand, gravel, and other hard-to-handle objects (grit chamber); and equalizing the temporal and mass variations of the wastewater (flow measurement and equalization).

Table 2. Wastewater treatment processes: Purpose and example technologies

Treatment stage	Purpose	Technologies
preliminary	removal of large solids and grit particles	screening, settling
primary	removal of suspended solids	screening, sedimentation
secondary	biological treatment and removal of common biodegradable organic pollutants	percolating or trickling filter, activated sludge; anaerobic treatment; waste stabilization ponds (oxidation ponds)
tertiary (or advanced)	removal of specific pollutants, such as nitrogen or phosphorous, color, odor, etc.	sand filtration; membrane bioreactor; reverse osmosis; ozone treatment; chemical coagulation; activated carbon

Primary treatment

The objective of primary treatment is to remove suspended solids from wastewater by gravity settling. The process continuously separates and withdraws solids as the water flows through a reactor with a hydraulic retention time ranging from 2 to 4 hours. Consequentially, contaminants associated with suspended solids are also removed. This process does not distinguish the chemical nature of the substances. Up to 50 to 70 percent of incoming suspended solids may be removed along with 25 to 50 percent of BOM and over 65 percent of the oil and grease. Domestic wastewater usually has a coliform bacteria count of greater than 10^6 per ml of water. While up to 90 percent of the microorganisms may be eliminated, the amounts remaining in the treated water are still considerably large after the primary treatment.

Secondary treatment

The effluent from primary treatment is further processed to remove residual BOM and suspended solids through secondary (biological) treatment processes in which the biodegradable dissolved and colloidal organic matters are decomposed. The microbial biomass and water mixture in the reactor must undergo gravity settling to clarify the water. Part of the settled biomass may then be recycled to maintain the cell culture. After secondary treatment, more than 95 percent of the suspended solids, 90 percent of the BOM, and 99.99 percent of the microorganisms are expected to be removed. Frequently, the treated effluent is then disinfected by chlorination before releasing.

Tertiary treatment

Although secondary treatment is the minimum standard under the CWA for wastewater treatment, tertiary treatment is becoming more common. Tertiary treatment includes a collection of unit processes that are intended to remove residual contaminants that interfere with water reuse or harm aquatic ecosystem functions when the finished water is discharged. Tertiary treatment commonly targets nitrogen, phosphorus, residual suspended solids, refractory organics, and dissolved minerals that are not entirely removed during secondary treatment. Depending on the target pollutant, tertiary treatment may include one or more of the following methods.

- **Coagulation, flocculation, and filtration** remove residual suspended solids in the colloidal size range that do not readily settle by gravitation. The colloidal particles frequently shelter microorganisms harmful to humans and are sources of residual BOM, nitrogen, and phosphorus. Chemical coagulants such as lime, alum, ferric chloride, and electrolytes cause the colloidal particles to coalesce and transform into the suspended state to be trapped during filtration.
- **Carbon adsorption** removes trace organic substances that are the sources of color, odor, and foul taste in the water. They may taint fish flesh, cause foaming, and kill fish. The process has also been shown to reduce the levels of endocrine disruptors and metallic ions such as cadmium, silver, selenium, and hexavalent chromium. This process is essential for reclaimed wastewater to meet California's total organic carbon (TOC) rules in groundwater recharge.
- **Nitrogen reduction** is necessary for surface water discharge, in which ammonium nitrogen should be less than 1 mg/l to safeguard the aquatic organisms, and the total dissolved nitrogen should be maintained as low as possible. For land applications, the nitrogen level in reclaimed wastewater may not need to be reduced. Nitrogen, one of the limiting nutrients that feeds nuisance algae in receiving waters, is only partially removed with secondary treatment. Depending on the operating conditions, nitrogen in treated effluent may be in the form of ammonium nitrogen and/or nitrate nitrogen. While processes have been specifically designed for nitrogen removal, the goal is frequently achieved by modifying the mass flow and operating conditions of the secondary treatment processes through which ammonia is oxidized into nitrate and then subsequently reduced to gaseous nitrogen.
- **Phosphorus control** is achieved through stepwise coagulation (flocculation) sedimentation processes that reduce the phosphorus concentration to less than 0.1 mg/l. Phosphorus can also be removed along with nitrogen during biological nutrient removal processes, when the phosphorus concentration of the finished water is expected to be between 1.0 and 2.0 mg/l. Like nitrogen, phosphorus is also an essential nutrient for algal blooms.
- **Membrane filtration** technology has been increasingly employed to obtain higher-quality water from wastewater and seawater. It is a separation process that excludes substances such as metal ions, viruses, bacteria, dissolved organic matter, and pesticides from the water stream, based on particle size, as the water being treated passes through the prescribed membranes under pressure.

Disinfection

Even after rigorous treatment, treated wastewater may still contain disease-causing pathogens. To safeguard the public from exposure, pathogens and bacteria of sanitary importance must be eliminated before treated wastewater is released. Depending on the intended reuses, many states have established specific disinfection requirements and/or performance standards for treatment processes.

Chlorination is the most common and reliable disinfection method. The unspent residual chlorine provides long-lasting residual disinfection power, preventing the water from being recontaminated before its final release; however, unspent chlorine may also pose potential harm to plants if the reclaimed water is used for irrigation (see the section "Disinfection byproducts," below). Ozone and ultraviolet radiation are increasingly being used as alternative methods for disinfecting reclaimed wastewater and are especially effective for eliminating viruses and protozoan cysts in the water.

The effectiveness of disinfection is susceptible to suspended solids in water that tend to shelter target organisms from the power of disinfectants. The reactions triggered by the strong oxidants and radiation energy may also change the chemical nature of trace organic substances in water, resulting in the generation of unintended disinfection byproducts (DBPs). These disinfection byproducts are characterized as emerging trace compounds of concern; they are potentially toxic and may have adverse effects on the environment.

Reclaimed Wastewater Quality Characteristics

Starting from the source, impurities in water rise incrementally with each cycle of use, even with treatment. Municipal sewage is typically greater than 99.9% water and less than 0.1% impurities of natural and anthropogenic origins. In addition to the chemical constituents, sewage also contains varieties of microbes, such as pathogens and bacteria, of sanitary importance. The composition of municipal wastewater is higbly variable (table 3) due largely to the unpredictability of volumes and substances discharged at each service connection. Even for a single community, the composition of impurities in the wastewater may vary seasonally as well as diurnally.

While current wastewater reclamation technology is capable of producing finished water of any desirable

Table 3. Typical range of effluent quality after secondary treatment

Constituent	TSS (mg/l)	BOD (mg/l)	NH3-N (mg/l)	Total N (mg/l)	Total P (mg/l)	Turbidity (NTU)	Total coliform per 100 ml
untreated wastewater	120–400	110–350	12–45	20–70	4–12	0	10^6–10^9
conventional activated sludge	5–25	5–25	1–10	15–35	4–10	2–15	10^4–10^5
conventional activated sludge + filtration	2–8	< 5–20	1–6	15–35	4–8	0.5–4	10^3–10^5
activated sludge + BNR	5–20	5–15	1–3	3–8	1–2	2–8	10^4–10^5
activated sludge + BNR + filtration	1–4	1–5	1–2	2–5	≤ 2	0.3–2	10^4–10^5
membrane bioreactor	≤ 2	< 1–5	< 1–5	<10*	< 0.3†–5	≤ 1	< 100
Activated sludge + microfiltration + reverse osmosis	≤ 1	≤ 1	≤ 0.1	≤ 1	≤ 0.5	0.01–1	~0

Key:
BNR = biological nutrient removal; BOD = biological oxygen demand; NTU = nephelometric turbidity units; TSS = total suspended solids.

Source: Adapted from Asano 2007.

Notes:
*With anoxic stage.
†With coagulant addition.

quality, municipal wastewater that has undergone the previously described *conventional* treatments will experience quality changes due to differences in source and treatment processes. The amount of impurities in reclaimed wastewater may accentuate the potential impact on water reuse. Some impurities are of agronomic significance while others are of public health significance. A detailed discussion about these water quality problems is given in the following sections.

Salinity

As the salinity level of reclaimed wastewater increases, the growth of sensitive plants may also be reduced. Salinity is frequently expressed in terms of total dissolved solids (TDS) or electrical conductivity (EC, measured in dS/m) of the water, but plants respond primarily to TDS. An approximate relationship between EC and TDS can be described by (Tanji 1990):

$$1 \text{ dS/m} \approx 700 \text{ mg/l (TDS)}$$

The salinity level in reclaimed wastewater is invariably higher than that in the source water, making it less attractive aesthetically for certain types of reuse. Problems due to salinity, however, may be alleviated with proper irrigation management and selection of tolerant plant species. Models to help manage salinity in irrigated cropland are also available, such as WATSUIT (see the University of California Center for Water Resources Web site, http://lib.berkeley.edu/WRCA/WRC/zip/Watsuit.zip).

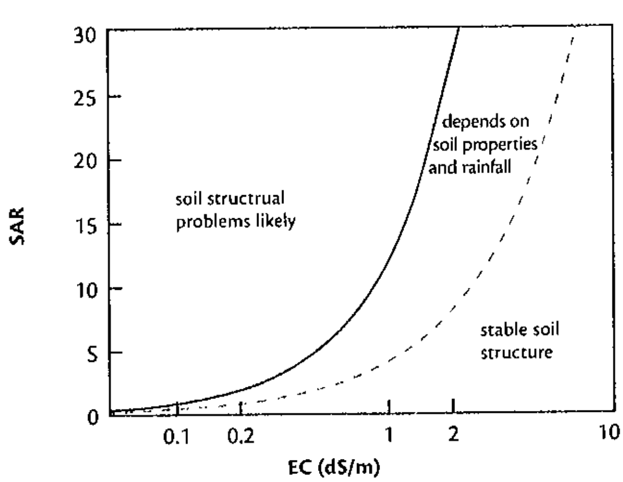

Figure 3. Relationship between sodium adsorption ratio (SAR) and electrical conductivity (EC) of irrigation water and likelihood of soil structure breakdown. *Source:* ANZECC and ARMCANZ 2000.

Sodicity

Changes in the mole fractions of Na+ versus Ca++ and Mg++ on the cation exchange sites of soils may be assessed by exchangeable sodium percentage (ESP) or by the sodium adsorption ratio (SAR). The ESP of a soil is calculated from:

$$ESP = [\text{exchangeable sodium (meq/100 g soil)} \div \text{cation exchange capacity (meq/100 g soil)}] \times 100$$

Since it is usually difficult to obtain reliable soil exchangeable cation data for calculating ESP, the SAR of soil solution, soil extract, or irrigation water is often used:

$$SAR = Na+ \div \sqrt{[(Ca{+}{+} + Mg{+}{+}) \div 2]}$$

where Na+, Ca++, and Mg++ denote the concentrations of respective cations of the water (meq/l).

When the ESP exceeds 15%, the higher level of Na+ on the exchangeable sites may cause the soil aggregates to collapse due to dispersion, which leads to poor water penetration and greater soil compaction. While this phenomenon occurs naturally in many soils, the commencement of irrigation with reclaimed wastewater will most likely accelerate soil property deterioration as the reclaimed wastewater is proportionally higher in Na+ than in Ca++ and Mg++.

In soils that contain very low to moderate amounts of exchangeable sodium (i.e., exchangeable sodium < 0.7 meq/100 g) and have sufficiently low cation exchange capacities, the adverse effects on soil properties may be lessened considerably or altogether nonexistent. Soil sodicity is tied closely to the chemical properties of the irrigation water. Irrigation water that has a high ratio of Na+ to Ca++ plus Mg++ and low salinity or contains calcium carbonate (CaCO3) caused by the precipitation of calcium with bicarbonate (HCO3–) may induce high sodicity.

Likewise, a high SAR can cause poor soil infiltration. Generally, irrigation water with high SAR value (i.e., SAR > 9) can severely restrict permeability when applied to fine-textured clay soils over a period of time. But the sodic (SAR) effect of water is often evaluated together with salinity. At the same SAR level, soil is more susceptible to dispersion in low-salinity water than in high-salinity water (fig. 3). In coarse-textured (sandy) soils, restrictions on permeability are less severe, and the water with this magnitude of SAR may be tolerated.

For details about salinity and sodicity, see *Saline and Alkaline Soils* (USDA Handbook 60, Richards 1954); on proper management of irrigated lands, see *Water Quality for Agriculture* (Ayers and Richards 1985).

Potentially toxic elements: Boron, chloride, sodium, and heavy metals

High levels of boron, chloride, and sodium in irrigation water are potentially harmful to plants. Heavy metal elements may accumulate in the receiving soils and harm plant growth or be transferred through the food chain to adversely affect consumers of the harvests.

Boron is by far the most likely element to harm plants irrigated with reclaimed wastewater. Small amounts of boron (i.e., < 0.5 mg/kg) are essential for plant growth, but at only slightly higher concentrations (> 0.5 mg/l in irrigation water), it may become toxic to plants. Plant tolerance to boron in soils varies widely. The threshold is established based on boron concentrations in soil saturation extracts; it may be as low as 0.5 mg/l for sensitive plants or greater than 16 mg/l for tolerant plants. (For more information about boron plant toxicity, see Rhoades et al. 1992.) Concentrations of boron in reclaimed wastewater principally originate from household detergents and cleansing agents and are not expected to be high enough to cause immediate harm to plants. However, boron may accumulate in the root zone through long-term use of reclaimed wastewater.

Chloride and sodium ions are major dissolved constituents of wastewater. In addition to their role in salinity, both chloride and sodium may be harmful to plants at high concentration (see Rhoades et al. 1992).

While trace elements such as arsenic (As), copper (Cu), chromium (Cr), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn) are found in municipal wastewater, conventional wastewater treatment processes effectively remove them from the water stream, and they concentrate in the sludge fraction. As a result, their presence in reclaimed wastewater is largely negligible and the concentrations are comparable to the levels found in fresh water. Based on past experiences in land application of reclaimed wastewater, trace elements do not constitute a problem in soil accumulation or through food chain transfer (see Asano 2007; O'Connor et al. 2008), but their fate and transport to groundwater remain largely unknown.

Nutrients

Reclaimed water can serve as a source of nutrients essential for plant growth, such as nitrogen, phosphorus, and potassium. These nutrients are beneficial to plants, but if not properly managed, they may cause many problems, such as nutrient imbalances, eutrophication of surface waters, and contamination of groundwater. Among them, nitrogen is the most noteworthy because significant amounts of nitrogen may be applied in a reclaimed wastewater irrigation operation. It is imperative that fertilization practices be adjusted to account for the added inputs from wastewater to avoid overapplication that may result in adverse impacts on water quality.

Chlorine residues

Chlorine residues are inherent to reclaimed wastewater; they gradually dissipate while the finished water is in storage. Excessive amounts of available free chlorine may cause leaf-tip burn and may damage sensitive crops if still present at the time of application. For turfgrass where water applications are frequent, the grass may become discolored over time and exhibit a slight yellow tinge. No scientifically based threshold values for plant injury are available, but a chlorine level less than 5 mg/l is considered to be safe.

Disinfection byproducts

When reclaimed wastewater is disinfected, the chemical oxidation process also produces disinfection byproducts (DBPs) that are primarily dissolved organohalogens derived from the oxidative breakdown of dissolved low-molecular-weight organic substances in water. Chlorination, the most commonly used disinfection process, produces more byproducts with relatively high concentrations than do other methods of disinfection. When reclaimed wastewater is chlorinated, it requires a high chlorine dosage and long contact time, conditions especially conducive to the formation of byproducts.

In chlorinated wastewater effluents, there may be hundreds of disinfection byproducts, of which only a small fraction has been identified. In general, byproducts may be grouped into the following: tribalomethanes, haloacetonitriles, haloketones, haloacetic acids, chloropbenols, aldehydes, trichloronitromethane, chloral hydrate, and cyanogen chloride. Among them, trihalomethanes and haloacetic acids are by far the most common and are often present at higher concentrations than tbe others, which are less frequently found. Under the most conducive condition for byproduct production (fully nitrified secondary effluents), the total chlorine levels in chlorinated reclaimed wastewater were found to be as high as 3,000 μg/l.

Long-term exposure to disinfection byproducts may cause cancers (Cantor et al. 1998; Hildesheim et al. 1998) or result in spontaneous abortion in the early trimesters of pregnancy (Swan et al. 1992). The likelihood of harm caused by disinfection byproducts is derived primarily from direct ingestion of chlorinated water. In crop irrigation, consumers may be indirectly exposed to them through food chain transfer or contamination of the underlying groundwater. Disinfection byproducts are, however, subject to volatilization in the ambient environment and are readily degraded through chemical and biological reactions. Because chlorinated reclaimed wastewater is typically stored until the time of irrigation, byproducts formed during disinfection are expected to decay during storage. After land application, those that remain after storage will continue to degrade in the soil and are not expected to accumulate.

It is also unlikely that disinfection byproducts pose a serious threat to groundwater underneath irrigated fields. Unless nonvolatile and refractory compounds are found in chlorinated reclaimed water, disinfection byproducts are not likely to be a limiting factor in reclaimed wastewater irrigation. However, one must be aware of their potential environmental harm and reassess the merit of reclaimed water irrigation if new information on their environmental fate becomes available.

Pathogens

The greatest health concern in using reclaimed wastewater for irrigation is directed to pathogens. Pathogens are inactivated through proper treatment and disinfection of wastewater. Reclaimed wastewater has been used for irrigation for many decades and thus far no scientific investigation has found that reclaimed wastewater irrigation has contributed to human illness. The potential for disease transmission through reclaimed water reuse, however, has not been completely eliminated. Thus, proper management is necessary to prevent disease transmission to humans by bacteria, parasites and viruses in reclaimed water (for more information, see Westcot 1997).

Epidemiological data is not available that shows any relationship between the quality of water actually applied at the field level and disease transmission or infection. The U.S. Environmental Protection Agency's guideline gives the maximum acceptable level for irrigation with natural surface water, including river water, as 800 fecal coliforms per 100 ml (EPA 2004). The World Health Organization's (2006) recommendation for wastewater use in agriculture is given in table 4. All the pathogens have the potential to reach the field, but many factors, including crop type, irrigation method, cultural and harvesting practices, and environmental conditions (e.g., temperature and humidity) can affect transmission of disease. Proper agronomic management can reduce and minimize the potential for disease transmission.

Pharmaceutically active chemicals and endocrine disruptors

Residues of over-the-counter and prescription drugs including antiphlogistics (such as ibuprofen and naproxen), lipid regulators, and beta-blockers have been found in treated wastewater effluents

Table 4. Recommended microbiological quality guidelines for wastewater use in agriculture

Type of irrigation		Required pathogen reduction by treatment (log units)	Verification monitoring level (E. coli per 100 ml)
unrestricted	root crops	4	$\leq 10^3$
	leaf crops	3	$\leq 10^4$
	drip irrigation of high-growing crops	2	$\leq 10^5$
	drip irrigation of low-growing crops	4	$\leq 10^3$
	verification level depends on the requirements of the local regulatory agency	6 or 7	$\leq 10^1$ or 10^0
restricted	labor-intensive agriculture	3	$\leq 10^4$
	highly mechanized agriculture	2	$\leq 10^5$
	pathogen removal in a septic tank	0.5	$\leq 10^6$

Source: WHO 2006.

(Xu et al. 2008). Among the pharmaceutically active ingredients, the residues of antibiotics and hormone-like compounds have attracted the most attention. Although conventional wastewater treatment is not designed specifically to remove these potentially harmful chemicals, the treatment processes nevertheless effectively reduce their concentrations in the treated effluents, usually to less than 10 μg/l.

In treated wastewater effluents, concentrations of drug and non-drug-related estrogenic chemicals have been reported in the ranges of 1 to 100 × 10^{-9} g/l and 0.1 to 30 × 10^{-6} g/l, respectively (Arcand-Hoy and Benson 1998). When the effluent is used for irrigation, the hormones increase the endogenous production of phytohormones in legumes like alfalfa. These phytohormones can then cause fertility problems in sheep and cattle that consume the forage (Tyler et al. 1998).

Some substances, though not hormones themselves, can disrupt the hormonal (endocrine) system in humans and other mammals (most notably aquatic organisms such as fish and amphibians). These endocrine disruptors (EDCs) are primarily synthetic chemicals that interact with endocrine systems and result in the disruption of normal biological functions, such as growth, development, and maturation. When interacting with the endocrine system of an organism, these substances may act like a natural hormone and bind to a receptor, interfere with the normal hormonal responses by binding and therefore blocking the receptor, or interfere with the organism's synthesis and control of natural hormones. Some substances exhibiting endocrine-disrupting properties include organochlorine pesticides (e.g., DDT, dieldrin, lindane, atrazine, trifluralin, and permethrin), surfactants (e.g., alkylphenols and their degradation products nonylphenol and octylphenols), plasticizers (e.g., dibutyl phthalate, butylbenzylphthalate, diethylhexylphthalate, and polyethylphthalate), PCBs, dioxins, and tributyltin. When exposed to high concentrations, adverse effects of select chemicals on the development and reproduction, cognitive and neurobehavior, and immunoresponses of exposed organisms have been demonstrated (National Research Council 1999).

There is inadequate technical information to assess the potential adverse impacts of endocrine-disrupting chemicals released during landscape application or agricultural irrigation of reclaimed wastewater. When they are present in the soil, certain linear alkylsulfanate surfactants (LAS) and their degradation byproducts (nonylphenols) are subject to rapid microbial degradation. They are also expected to be adsorbed to the soil organic matter. As a result, they are not likely to enter the plant tissue through root absorption. However, if wastewater is released to natural water bodies, the potential ecotoxicological consequences cannot be overlooked.

Other water quality indicators

The following brief description of water quality indicators does not indicate these indicators are not as important as water quality parameters. These indicators are less specific to reclaimed wastewater, and information about them is widely available.

- **pH.** One of the most important parameters that affects metal solubility as well as alkalinity of soils.
- **Biodegradable** organics. Measured by BOD, COD, or TOC. Biodegradable organics cause aesthetic and nuisance problems, adversely affect disinfection processes, and deplete soil oxygen.
- **Stable (refractory) organics.** Organic compounds such as phenols, pesticides, and chlorinated hydrocarbons are resistant to degradation in conventional methods of wastewater treatment. Some are toxic in the environment and may accumulate in the soil.

Reclaimed Wastewater Applications for Agriculture and Landscape

Reclaimed wastewater is most commonly used for irrigation and environmental enhancements that include landscape and turf irrigation, decorative fountains and landscape impoundments, and crop irrigation. With proper treatment of water and proper field management, reclaimed water can be used safely in these settings. The degradation in soil properties and potential for plant injuries associated with the incremental increases in salinity and harmful elements are also manageable issues.

Safe Use of Reclaimed Wastewater

When reclaimed wastewater is used for agriculture and landscape irrigation, certain measures must be taken to ensure safe use.

Setback distances

The setback distances, or buffer zones, between reuse sites and other facilities such as potable water supply wells, property lines, residential areas, and roadways are added safeguards. The actual distances depend on the quality of the reclaimed water and the method of application. For example, Nevada's regulations require a buffer of 400 to 800 feet, depending on disinfection level, for a spray irrigation system, while no buffer is required for surface application of reclaimed wastewater (see Nevada Administrative Code, Chapter 445A). Table 5 summarizes the guidelines suggested by the EPA (2004) regarding water quality monitoring and appropriate setback distances.

Cross-connection control

Cross-connections between reclaimed water and potable water delivery systems should not exist, and all possible measures must be exercised to prevent such cross-connections from occurring. Generally, prevention provisions are stipulated in the plumbing codes and are achieved through installation and regular testing of backflow prevention and air gap separation devices. The cross-connection prevention plan of a water reuse project is subject to the review and approval of the permitting agencies and reclaimed water purveyors prior to the installation.

Salinity management

When leaching is not required, the water needed for normal plant growth is equal to evapotranspiration (ET). However, additional water is often required for leaching in order to keep salinity in check. This leaching requirement (LR) depends on the salinity of irrigation water (ECw, dS/m) and the crop tolerance to soil salinity (ECe, dS/m), which can be estimated based on the following equation:

$$LR = ECw \div (5 \times ECe - ECw)$$

Therefore, the total amount of applied water (AW) to meet both the crop demand and leaching requirement can be estimated by

$$AW = ET \div (1 - LR)$$

Application rates and times

How much water to apply and when to apply it are often a part of the water reuse plan. The maximum application rate is governed by the hydraulic loading capacity of the receiving soils. When reclaimed water is used in groundwater recharge, there is a tendency

Table 5. EPA guidelines (2004) on water quality monitoring and setback distances

Use category	Monitoring requirement	Setback distance
urban reuse or agricultural reuse: food crops not commercially processed	weekly: pH and BOD daily: coliform continuous: turbidity, Cl2 residue	15 m to potable water supply wells
restricted access area or agricultural reuse: food crops commercially processed; agricultural reuse: nonfood crops	weekly: pH and BOD daily: TSS, coliform continuous: Cl2 residue	90 m to potable water supply wells; 30 m to areas accessible to the public, if spray irrigated
recreational impoundments	weekly: pH and BOD daily: coliform continuous: turbidity, Cl2 residue	150 m to potable water supply well, if bottom not sealed
landscape impoundments	weekly: pH daily: TSS, coliform continuous: Cl2 residue	150 m to potable water supply wells, if bottom not sealed
industrial reuse: cooling water	weekly: pH and BOD daily: TSS, coliform continuous: Cl2 residue	90 m to areas accessible to the public
environmental reuse (wetlands, steam augmentation)	weekly: BOD daily: TSS, coliform continuous: Cl2 residue	not applicable
groundwater recharge	depends on treatment and use	Site-specific

Source: EPA 2004.

to push the application rate to the maximum. When reclaimed water is used for irrigation, the hydraulic loading rates are more likely dictated by the plant requirements in terms of evapotranspiration, nutrient intake, and salinity tolerance; therefore, the rates are generally site-specific in accordance with best management practices. The timing of reclaimed water applications may be scheduled to minimize potential direct human contact with any spray or aerosols. For example, the Irvine (California) Ranch Water District requires that the public parks, golf courses, and public and private landscaping receiving reclaimed water must irrigate during the off-hours between 9:00 pm and 6:00 am (IRWD 2002).

Water Quality Issues

Recycled water is wastewater treated to a quality high enough to be safe and effective for approved uses such as landscape irrigation. It is clear, odorless, and free of harmful bacteria. However, it typically does contain more salts and nutrients than those found in potable water. Some of these constituents can be beneficial to landscapes, while others may be harmful. For example, nitrogen, calcium, and magnesium can help to enrich a soil and reduce the need for commercial fertilizers. On the other hand, excessive concentrations of sodium, chloride, and boron can harm plant and soil health (see the section "Physical, Chemical, and Biological Characteristics of Reclaimed Wastewaters," above, for more details). Although the chemical properties of recycled water depend on the treatment facility, generally the only compound remaining after treatment that is potentially harmful to landscape plants is sodium chloride. Other elements such as boron, selenium, magnesium, and cadmium are rarely found to be above safety levels. Since most landscape plantings are not monocultures (one crop) as they are in agriculture, salt concentrations in recycled water must be acceptable for wide ranges of landscape plant species.

Landscape Irrigation Using Reclaimed Wastewater

Distribution of reclaimed wastewater

In the arid southwest, a significant proportion of urban water use is for outdoor landscape maintenance. The potential for using reclaimed wastewater in landscape irrigation is realistic where a conveying system exists to distribute the water. While a limited number of communities in the United States have dual and separate water distribution systems for potable and nonpotable water, most water reuse projects must include capital investment on infrastructure to distribute the reclaimed wastewater. The nonpotable supply may be used for landscape irrigation and toilet flushing (especially in high-volume commercial and business facilities), while the potable supply provides water for drinking, food preparation, and other indoor household uses. Unless reclaimed wastewater is readily accessible in the community, the lack of an established distribution network will restrict the extent of the reuses. No single factor is likely to influence the cost of water reclamation more than the conveyance or distribution of reclaimed water from its source to its point of use.

A distribution network includes pipelines, pump stations, and storage facilities. The design of distribution facilities is based on topographical conditions as well as reclaimed water demands. If the topography has wide variations, multilevel systems may have to be used. Figure 4 provides a schematic of the various reuse conveyance and distribution systems that may be encountered. During the design, the most important considerations are the reliability of service and protection of public health. The following safeguards must be considered during the design of an urban reclaimed water distribution system.

- The recycled water agency must assure that the reclaimed water delivered to the customer meets the water quality standards for the intended uses.
- Variations in the demand for reclaimed water occur seasonally. Large volumes of seasonal storage may be needed if all available reclaimed water is to be used, although this may not be economically practical. The selected location of a seasonal storage facility will also have an effect on the design of the distribution system.
- To prevent the misuse of reclaimed water, piping, valves, and hydrants should be marked or color-coded (e.g., purple pipe) to differentiate reclaimed water from potable water.
- Where a dual distribution system is created, the design will be similar to that of a potable system in terms of pressure and volume requirements. However, if the reclaimed water distribution system does not provide for an essential service such as fire protection or sanitary uses, the reliability of the reclamation system need not be as stringent.
- There should be no cross-connection between potable and reclaimed water lines. The American Water Works Association recommends that effluent distribution lines be buried at least 1 foot deeper

than the domestic water lines and be operated at a lower pressure differential (AWWA 1994).

- If potable water is to be used as a backup source to the recycled water system, the potable water should be separated by an air gap separation mechanism approved by the appropriate regulatory agencies (for example, the state Department of Health Services and the local city or county health department). A reduced-pressure-principle backflow prevention device or a double check valve should also be installed at the potable water service connection.
- If the service pressure is higher than the user can accept, the user is generally responsible for providing a pressure reducing valve downstream of the service meter. If the service pressure is lower than what the user needs, the user is responsible for providing booster pumping downstream of the meter. Any pumping of recycled water requires the prior written approval of the recycled water agency.

Management practices

In addition to water quality, many other important factors must be considered when irrigating landscape plants with recycled water. Some of these include the frequency of irrigation, quantity of water applied, method of application, and water-holding capacity of the soil. Proper site management, and specifically, proper water management, is the key to successful landscaping with recycled water.

The basic principles of managing irrigated landscaping do not distinguish whether the source water is a reclaimed wastewater or a potable source. These principles require managers to have full knowledge of the quality of the applied water and to adjust the practices according to the salinity, nutrient

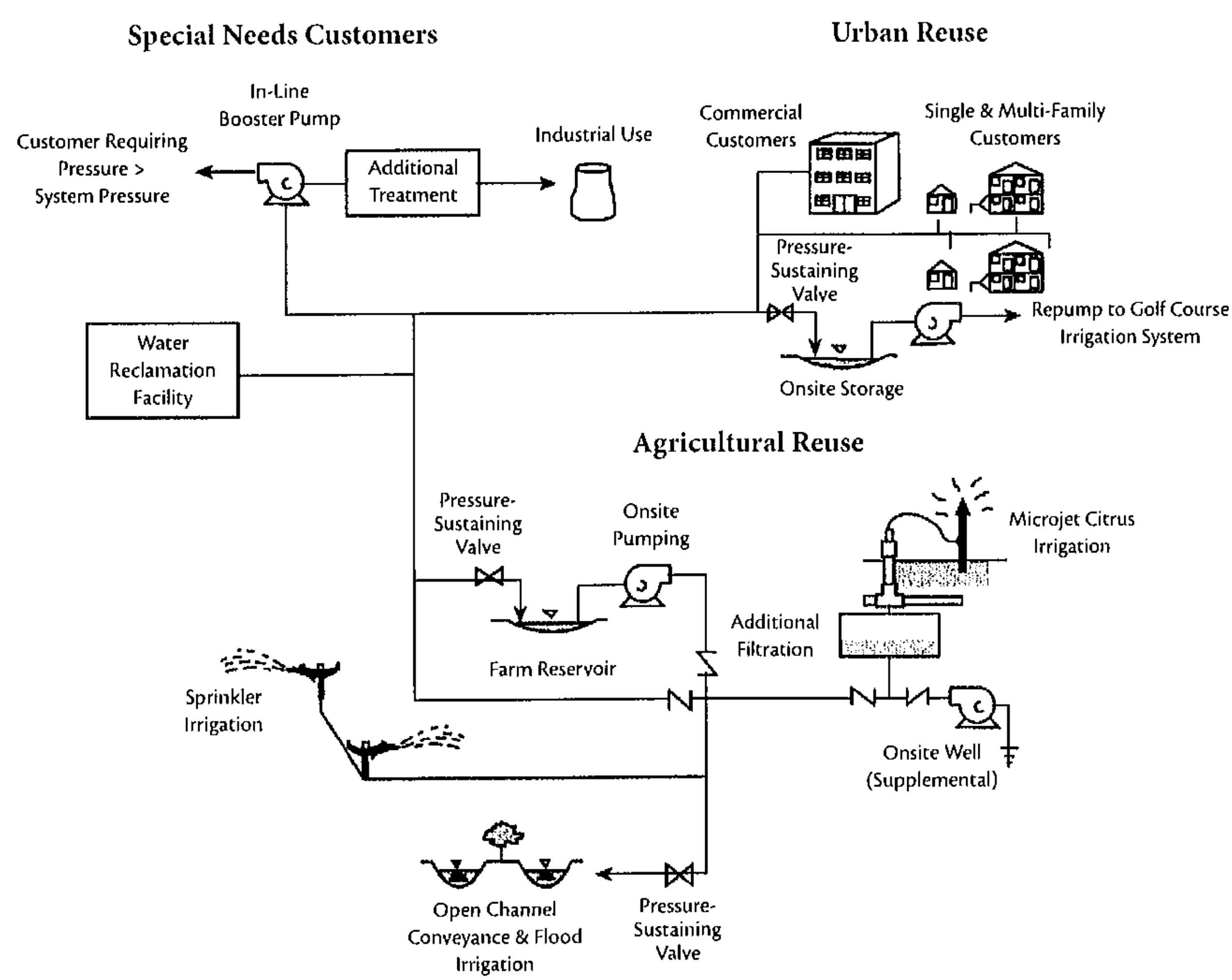

Figure 4. A multiple reuse distribution system. *Source:* EPA 2004.

contents, and toxic chemical contents of the water. The following elements should be factored in to the field water management scheme.

- Inclusion of appropriate methods and equipment for water application to improve the control of irrigation efficiency and soil salinity and to minimize public health risks. For example, some plant species that show a sensitivity to direct leaf contact with spray irrigation show no sensitivity when irrigated with soil-applied or drip irrigation. In any event, infrequent, heavy irrigation should be applied rather than frequent, light irrigation. This allows the leaf surface and the soil to dry out between irrigations, minimizing or eliminating salt stress damage. Improving drainage by means of cultivation, adding organic matter to the soil, and adding gypsum also greatly aid in limiting any damage from salt buildup in the root zone.
- Consideration of plant tolerance to salinity and boron in landscaping designs.
- Employing chemical amendments (i.e., gypsum, lime, sulfur, and organic matter) to modulate nutrient availability, SAR, and pH of receiving soils.
- Using buffer zones where low-quality (secondary and lower) reclaimed water is used.
- Blending reclaimed water with water sources that have a lower SAR or lower TDS, if necessary and feasible, through seasonal use of alternate sources of water or real-time blending with such water.
- Balancing fertilization with the amount of fertilizer present in reclaimed water.
- Providing an adequate leaching fraction and good drainage, especially on golf course greens and other intensely played surfaces.

For details, readers are referred to the management practices outlined in *Water Quality for Agriculture* (Ayers and Westcot 1985).

Table 6. Effluent quality (in mg/l, except as specified) of Michelson Water Reclamation Plant

Parameter	Range	Average	Limit
biochemical oxygen demand	ND–11	ND	20
chemical oxygen demand	12–41	23	NA
chlorine residual	3.2–17.1	10.0	NA
electrical conductivity (μmhos/cm)	538–1265	892	NA
pH (–)	6.5–6.8	6.6	6.5–8.5
total dissolved solids	566–812	680	720
suspended solids	ND–4.5	1.3	20
turbidity (NTU)	0.4–2.0	1.0	2.0
coliform bacteria (MPN/100ml)	ND–23	ND	2.2
arsenic	ND–0.0029	0.0016	0.05
boron	0.28–0.59	0.5	1
cadmium	ND–0.0002	ND	0.01
chloride	102–183	137	150
chromium	0.0007–0.0041	0.0017	0.05
cobalt	0.0003–0.0007	0.0005	0.2
copper	0.0032–0.0083	0.0060	0.02
fluoride	0.28–0.55	0.45	1.0
lead	0.0016–0.0050	0.0033	0.05
mercury	ND–0.0007	ND	0.002
nitrate (as N)	2.9–5.5	4.5	NA
total N	6.9 – 13.0	8.57	NA
phosphate, ortho (as P)	0.2–2.9	1.2	NA
potassium	14.3–37.3	20	NA
sodium	116–142	129	125
zinc	0.0388–0.0867	0.0666	0.1

Key: NA= not analyzed; ND = not detected; NTU = nephelometric turbidity units.
Source: IRWD 2006.

Case study: William R. Mason Regional Park, Irvine, CA

The first phase of Mason Park opened to public use in 1973 with 45 acres; a 50-acre second phase, including a 9.2-acre lake, was completed in 1978. The artificial lake in the center of the park is a popular attraction for visitors as well as for migrating birds and other local wildlife. Treated wastewater (tertiary or advanced treatment) from Irvine Ranch Water District's Michelson Water Reclamation Plant (MWRP) is used at the park for irrigation and for filling the lake. The reclaimed water produced at MWRP carries an unrestricted use permit from the California Department of Public Health. This water meets the stringent requirements of Title 22 of the state Health Code and is of such high quality that it can be used for everything but drinking. Water quality constituents within detectable limits are given in table 6.

Based on the characteristics of the reclaimed water, irrigation scheduling and practices for the park were developed to minimize potential adverse impacts on people as well as on the environment. Proper management of irrigation with reclaimed water has enabled the park to provide a recreational and scenic resource to the community without using potable water supplies. These management practices include the following.

- By recognizing that reclaimed water usually contains high salt concentrations, additional water should be applied as a "leaching requirement" to wash out the excessive salt accumulation.
- Reclaimed water contains certain amount of nutrients; therefore, lawn fertilization should account for the amount of nutrients in the reclaimed water.
- Long intervals should be used between irrigation events to stimulate deep root growth and facilitate ground maintenance and public enjoyment.
- During irrigation events, short and frequent water application should be used to reduce surface runoff. For example, if the total irrigation run time is 15 minutes, this period is divided into 3 running times of 5 minutes on separated by 5 to 10 minutes off.
- The landscape should be irrigated between 10 pm and 7 am to minimize the public's direct exposure to reclaimed water.
- Plant species should be selected that are more tolerant to salinity. Adjustments were made after several tree species did not grow well using reclaimed water, mainly because of the relatively high salinity level.
- Reclaimed water should be prevented from making contact with wood structures. Plastic materials and galvanized steel rather than wood should be used to avoid the relatively fast decay of wood materials, and they should be painted more frequently to reduce rust and decay.
- Lavatories and drinking fountains should be bleached to reduce the potential for human exposure to pathogens. Drinking fountains near turf areas may come in contact with the reclaimed water through spray from sprinklers.
- No diving or swimming is allowed.

Reclaimed Wastewater Applications in Agriculture

Success in using reclaimed wastewater for crop production largely depends on adopting appropriate strategies to optimize crop yield and quality, maintain soil productivity, and safeguard the environment. In general, application of reclaimed wastewater for agriculture follows the same principles as for landscape irrigation as discussed in the previous section. Therefore, the following sections focus primarily on management practices specific to agricultural irrigation using reclaimed wastewater.

Management practices

Irrigation run time. Many irrigation systems are designed to apply water for short periods of time, perhaps many nights a week. Compared to longer irrigation run times done on a less frequent basis, short irrigation runs can deposit more salt in the root zone, with possible adverse impacts on plant health and growth. Heavier watering done less frequently leaches the accumulating salts out of the root zone.

Amount of water applied. In addition to the irrigation run time, the amount of water applied is also an important factor to prevent accumulation of salts in the soil. Insufficient irrigation leads to a decrease in crop production due to salinity accumulation in the crop root zone. However, excessive flooding can inhibit aeration, leach nutrients, induce secondary salinization, and pollute groundwater. Irrigation requirements depend on the crop, the stage of plant growth, and climatic conditions. A computer program, CROPWAT, can be downloaded from tbe FAO website to determine the water requirements of various crops from climatic data from almost all continents (http://www.fao.org/ag/AGL/aglw/cropwat.stm).

Irrigation method. Reclaimed wastewater may be applied by all modes of irrigation, depending on the specific situation. From a health aspect, drip irrigation systems provide the best protection as they are totally closed systems and avoid the problems of worker safety and drift control. However, drip irrigation requires strict maintenance for proper operation. Clogging problems are likely to occur, particularly with effluents from primary sedimentation and oxidation ponds. The suitability of a given water source for use in drip irrigation systems can be evaluated based on the guidelines proposed by Hanson et al. 1997 (table 7). In addition to health considerations, the financial cost as well as salinity buildup and toxicity hazards associated with different irrigation methods should be also taken into account.

Fertilizer adjustment. Growers should take into account the value of nutrients in reclaimed water and reduce consumption of fertilizers accordingly. They should also keep in mind the risk of oversupplying nitrogen when irrigating with recycled water. For example, if the reclaimed water contains an average total nitrogen of 10 mg/l (or 10 g/m^3), the total nitrogen input from 1 acre-foot of the water will be

10 g/m^3 × 1 AF × 1,233 m^3/AF = 12330 g/AF, or 27.2 lb/AF

Excess nitrogen (over 30 mg N_{tot}/l) can reduce crop quality and may exacerbate deficiencies of other nutrients, such as phosphorus or potassium, if these are not provided in appropriate ratios. To optimize crop yield and quality, additional fertilizers may be supplied during specific crop growth stages. If the reclaimed wastewater is high in nitrogen content, it is desirable to choose plant species with a high nitrogen demand to reduce the possibility of deep nitrogen percolation and groundwater pollution.

Air quality considerations. Although no data are available to quantify the amount of the nitrogen volatilization, sprinkler irrigation of reclaimed wastewater may release some of the ammonia to the air, which may contribute to the formation of PM 10 (see EPA 2008).

Case study: City of Bakersfield Reclaimed Wastewater Application Field

Adjacent to the city of Bakersfield, California, is a municipal farm of greater than 2,000 hectares that has been continuously cultivated and irrigated with an annual average of 0.8 to 1.2 meters (depending on the crop rotation) of reclaimed municipal wastewater for over 80 years. The reclaimed water is stored in reservoirs and used to fulfill seasonal demands of irrigation for greenchop winter grain forage (*Hordeum* and *Triticum* spp.), corn grain and silage *(Zea mays)*, wheat *(Triticum sativum)*, cotton *(Gossypium hirsutum)*, alfalfa *(Medicago sativa)*, and sorghum *(Sorghum vulgare)*. During this 80-year period, the wastewater collection and treatment system has continuously evolved in response to both the growth of the city and regulatory requirements. As inflows and outflows of the reservoirs fluctuated dynamically with supply and demand, no record was kept of the chemical characteristics of the applied water. However, recent measurements indicate that the electric conductivity of the effluent from the treatment plant is about 0.7 to 0.9 dS/m, with an SAR of about 3.

A second field, considered as a control field with the identical soil series and elevation aspect, is located one-half mile west of the treated field. For approximately an equal length of time, this field has been cultivated with similar crops using very low-salinity Kern River water supplied by the Kern Delta Water District.

Soils in these two fields were sampled in September 1998, at the end of the growing season (Wang et al. 2003). One hundred soil samples were taken at 1-meter intervals along a 100-meter transect perpendicular to the direction of irrigation furrows and approximately 150 meters down field from the heads of the furrows. For this study, 29 physical, chemical, and biological attributes of the soils at the treated field and its adjacent nontreated control field were determined. Except for the total porosity and magnesium, the soil parameters of the control and treated fields were not significantly different. While the soils of both fields support successful crop production,

Table 7. Water quality and clogging potential in drip irrigation systems

		Degree of restriction on use		
Potential problem	**Units**	**None**	**Slight to moderate**	**Severe**
suspended solids	mg/L	< 50	50–100	> 100
pH	—	< 7.0	7.0–8.0	> 8.0
dissolved solids	mg/L	< 500	500–2,000	> 2,000
manganese	mg/L	< 0.1	0.1–1.5	> 1.5
iron	mg/L	< 0.1	0.1–1.5	> 1.5
hydrogen sulfide	mg/L	< 0.5	0.5–2.0	> 2.0
bacterial populations	max. number/L	< 10,000	10,000–50,000	> 50,000

Source: Hanson et al. 1997.

the reclaimed wastewater irrigation appeared to only slightly increase the soil compaction and reduce the soil's capacity of holding nutrient elements, such as magnesium.

For the successful application of treated wastewater in agricultural production, growers should consider adjusting nitrogen fertilization and salinity management. Nitrogen in treated wastewater can range from 5 to 20 mg/l (50 to 200 kg/ha per meter of water applied) since secondary treatment does not remove nitrogen from the effluent. At the higher concentration, the amount of nitrogen in reclaimed wastewater irrigation can meet the nitrogen requirements of most crops. For cotton, this nitrogen often causes excessive growth later in the season. To correct this problem, growers now use the treated wastewater containing beneficial nitrogen for early-season irrigation and switch to well or canal water with low nitrogen in the later season, or blend the treated wastewater with other waters to reduce the nitrogen input. For the Kern County site, however, concentrations of nitrate-nitrogen are usually below 10 ppm and rarely cause this type of problem.

Another issue for this site is the high salinity and sodicity of the soil, as is the case with over half the city's farmland. To manage this issue, additional leaching is necessary for the field receiving wastewater irrigation. This field is heavily irrigated using flood or furrow irrigation, with gypsum and lagoon scrapings applied every 2 or 3 years to improve infiltration. Due to the extremely low salinity of the Kern River water, gypsum is also occasionally applied to the control field.

Proper management of irrigation with reclaimed wastewater has enabled this farm to achieve successful crop production comparable to irrigating with fresh canal water.

Conclusion

Reclaimed wastewater has been successfully applied in many parts of the world, including the southwestern United States. As demand for high-quality water increases, more agricultural land and landscapes will depend on wastewater as a source for irrigation. Safe and successful application of wastewater involves careful planning of the wastewater application projects, implementation of safety guidelines, and proper management according to the soil, crop, and water characteristics.

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English–Metric Conversions

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)
mile (mi)	1.61	0.62	kilometer (km)
acre (ac)	0.4047	2.47	hectare (ha)
fluid oz (oz)	29.57	0.338	milliliter (ml)
quart, liquid (qt)	0.946	1.056	liter (l)
quart, dry (qt)	1.1	0.91	liter (l)
gallon (gal)	3.785	0.26	liter (l)
acre-foot (AF)	1,233	0.000811	cubic meter (m^3)
ounce (oz)	28.35	0.035	gram (g)
pound (lb)	0.454	2.205	kilogram (kg)
ton (T)	0.907	1.1	metric ton (t)

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STANFORD
UNIVERSITY

April 17, 2009

Ms. Valerie Fong
City of Palo Alto Utilities
250 Hamilton Avenue
Palo Alto, CA 94301

Re: Initial Study/Mitigated Negative Declaration for Palo Alto Recycled Water Project

Dear Ms. Fong:

Stanford University appreciates the opportunity to comment on the draft Initial Study/Mitigated Negative Declaration for the City of Palo Alto's Recycled Water Project.

Stanford supports efforts to decrease potable water use using water resources efficiently, implementing water conservation measures, and incorporating water-efficient infrastructure into new facilities. However, the draft IS/MND presents several serious concerns regarding the environmental impacts that would result from Palo Alto's Recycled Water Project. Stanford's major concern relates to the adverse effects on trees due to the increased salinity in the irrigation water. As the IS/MND recognizes, recycled water contains more salt than typical irrigation water derived from potable supplies and this increased salt content can adversely affect trees such as coastal redwoods that are sensitive to salinity. Unfortunately, the IS/MND declines to make a significance finding on this critical issue. Given the importance of redwood trees to the City's urban landscape and to the appearance and value of the Stanford Research Park in particular (which the Recycled Water Project is designed to serve), the IS/MND should include a finding on whether the impact on trees from using high salinity irrigation water is significant. As discussed below, we believe the facts show that this is a significant impact.

The IS/MND includes an Adaptive Management Program that is designed to detect and respond to adverse effects on trees, but there are significant concerns as to whether this program will adequately protect redwoods and other trees *after* they have *already* been exposed over time to high salinity irrigation water. The program also defers analysis of adverse impacts to a future date, and it is not clear whether the program is feasible given the extent and expense of the future studies that would be required.

STANFORD REAL ESTATE OFFICE
2755 Sand Hill Road, Suite 100 • Menlo Park, CA 94025 •T: 650.926.0300 • F: 650.854.9268

Stanford's second concern relates to the facilities that the City plans to install at the Mayfield Soccer Fields. The IS/MND states that there will be no significant impacts resulting from these facilities based on the fact that the Project will be subject to the City's design review process in the future. The IS/MND should include a complete evaluation now of the aesthetic and land use impacts associated with locating Project facilities at the Mayfield Soccer Fields, and of any mitigation measures necessary to lessen those impacts, instead of deferring this evaluation to a future process that will only occur after the City has already approved the Project.

Finally, the IS/MND relies on deferred mitigation for impacts to biological resources. The IS/MND should clarify the specific measures that will be used, so that their effectiveness can be fully evaluated before the Project is approved.

Each of these concerns is discussed separately below. Stanford looks forward to working cooperatively with the City to resolve these issues.

A. The Impacts Resulting from Increased Salinity Warrant a Finding of Significance and a More Complete Environmental Evaluation

As the IS/MND recognizes, "[r]ecycled water is characteristically higher in alkaline salts than typical irrigation water derived from potable supplies and may cause decline in acidic favoring tree species." IS/MND at p. 73. The IS/MND explains that even after inflow and infiltration controls to reduce the intrusion of salty groundwater into the sewer collection system, recycled water from the Palo Alto Regional Water Quality Control Plant would have a total dissolved solids of 700 milligrams per liter, as compared to 100-300 mg/l in the existing water supply. *Id.* at pp. 73, 76. The IS/MND further explains that a recent study "found that Palo Alto recycled water was the most saline recycled water studied." *Id.* at p. 75, fn.14 (citing Oster 2009).

The IS/MND further recognizes that salts can build up in poorly drained soils. As the IS/MND explains:

> [S]alt buildup in poorly drained soil may create a long-term inability of the soil to absorb and provide water availability to the tree roots. . . . Because salts are not absorbed by the vegetation or broken down in the subsurface, they have the potential to build up in the root zone in poorly drained soils and affect tree health. *Id.* at 73.

In turn, soils with higher silt and clay content are more affected by salt buildup than other soils, because they are less well drained. See *id.* at p. 75 ("soils with higher silt and clay content are more affected by water quality than other soils"). For this reason, HortScience has recommended that "[u]se of recycled water should be avoided in areas of poor drainage, since those areas cannot be leached." Nelda Matheny and James R. Clark, *Designing Landscapes Using Recycled Water* (dated Nov. 17, 2005) at p. 2.

This is a significant issue for the Stanford Research Park. Based on Stanford's experience with various projects at the Stanford Research Park, subsurface conditions consist of predominately moderately to highly expansive clays overlying interbedded layers of sands and clays, with the sand layers tending to contain clayey or silty fines. In other words, the soils at the Stanford Research Park are the types of soil that are susceptible to salt buildup.

Additionally, the IS/MND recognizes that certain tree species, such as coastal redwoods, are particularly sensitive to salinity. See, e.g., IS/MND at p. 75 (coastal redwoods are sensitive to total soil-water salinity regardless of the type of salt causing the salinity). HortScience explains generally that, as irrigation water is applied to soils, some of the salts in the water remain in the soil. "As these salts accumulate in the soil, plant toxicity may occur. Salt toxicity is first expressed as stunting of growth and yellowing of foliage. Burning of the edge of leaves and defoliation usually occurs. In severe cases, plants are killed." Matheny and Clark, *Designing Landscapes Using Recycled Water*, at p. 2.

Further, as Oster's recent study points out, "Coastal redwood is the primary plant species of concern. Observed leaf burn and tree death have been associated with irrigation with recycled water, indicating coastal redwood is very sensitive to salinity, sodium, chloride or a combination of all three." Oster 2009, at p. 1. The 2007 study by Barnes et al. similarly explains:

> Sodium and chloride, two of the main constituents in the treated recycled water, have been suspected of causing the decline of redwood trees in the California South Bay Area where this water has been used to irrigate public landscapes such as parks and golf courses. Symptoms noted on some redwoods irrigated with recycled water include leaf necrosis and in severe cases, branch and whole tree death.

Barnes et al. 2007, at p. 2. The study concludes that "[t]he response of *Sequoia sempervirens* 'Aptos Blue' to the salinity treatments in this study indicates a ***clear increase in detrimental effect*** with increasing treatment concentration." *Id.* at p. 26 (emphasis added). In an email communication to Stanford, Nelda Matheny of HortScience summarizes the problem as follows:

> [M]y experience with redwoods is that they are very sensitive to salts and usually begin to show toxicity symptoms within one to years of its application. Redwoods must be irrigated frequently because they have no drought tolerance. Each irrigation adds salt, and over time the salts in the soil accumulate to damaging concentrations. I have observed mature redwoods significantly damaged after 3 years of irrigation with recycled water.

Email communication from Nelda Matheny to Jim Inglis (Apr. 17, 2009). In addition to redwoods, HortSciences has identified a number of other salt sensitive plant species, such as Japanese maple, crape myrtle, southern magnolia, London plane, wisteria, etc., which may be harmed by use of recycled water. Matheny and Clark, *Designing Landscapes Using Recycled Water*, Table 3. The Stanford Research Park contains many redwoods and other plant species that could be negatively affected by high salinity irrigation water.

Not surprisingly, the IS/MND recognizes that when trees are exposed to increased stress by an environmental change such as irrigation with recycled water with a higher salt content, "they may exhibit signs of decline." IS/MND at p. 75. The IS/MND further recognizes that "increased salt content in the recycled water and poor drainage could affect the biological health, appearance (dieback), or mortality of existing protected, street, and designated trees." *Id.*

The IS/MND, however, declines to make a finding of significance regarding this impact, based on the statement that there is no definitive correlation between recycled water use and the decline in redwood trees. *Id.* at p. 74. Stanford does not believe this is a correct statement given the current state of the scientific evidence, which shows that increased salt content in irrigation water can have significant adverse effects on redwood trees. In any case, to the extent there are any disputes, uncertainties or unresolved issues in the scientific record, the matter should be resolved through the full EIR process, not through the adoption of a Negative Declaration.

The IS/MND contains an Adaptive Management Program that is designed to detect and respond to adverse impacts to trees, but there are several concerns regarding the program's effectiveness and feasibility. First, the program is not proven and it is unclear whether the measures in the program will be effective. As explained in Oster's recent study, "[w]ith even the best management, excess salinities may not be preventable." Oster 2009, at p. ii. As Nelda Matheny of HortSciences explains:

> I do not think that it is possible to maintain healthy redwoods with recycled water containing high concentration of sodium and chloride using conventional techniques and water-conserving irrigation schedules. It ***may be possible*** with adjustments to management practices such as leaching, abundant irrigation, and application of amendments to help leach salts. ***These modifications have yet to be tested in field applications.***

Email communication from Nelda Matheny to Jim Inglis (Apr. 17, 2009) (emphasis added). For this reason, HortSciences recommends avoiding use of recycled water with salt sensitive species such as coastal redwoods. HortSciences recommends that if salt sensitive plantings cannot be avoided, irrigation of these plantings should use "separate systems providing potable water." Matheny and Clark, *Designing Landscapes Using Recycled Water*, at p. 5 & Table 3. Another recent publication on the use of recycled water for irrigation similarly explains that plant species should be selected that are more tolerant to salinity, as several tree species "did not grow well using reclaimed water, mainly because of the relatively high salinity level." Laosheng Wu et al, *Safe*

Application of Reclaimed Water in the Southwestern United States (March 2009) (UC peer reviewed/Publication 8357), at p. 17.

Another problem is that the Adaptive Management Program is designed to address salinity impacts only *after* redwoods and other landscaping have been exposed over time to high salinity irrigation water and adverse impacts have been observed. But by that time, the program may be too late to reverse the negative effects. As Oster's recent study notes, "[s]ince salinity damage to trees is difficult to reverse, it may be that a reduction in salinity of the applied water, once recycled water has been used for several years, will not be effective in saving trees." Oster 2009, at p. ii.

Third, the program is based on future studies that are designed to determine whether the impacts on trees from high salinity irrigation water are adverse, how adverse those impacts are, and how the impacts will be mitigated. The IS/MND should not defer the evaluation of these important Project issues to a future date.

Fourth, the program requires an expensive set of baseline, monitoring and landscape studies -- all leading to a potential end result of ceasing recycled water use due to adverse effects on landscaping, or replacing trees that have died as a result of such adverse effects with salt tolerant species. This raises the question of who will pay for the studies and how they will be implemented -- and more broadly whether the Adaptive Management Program would be an effective, cost-effective and feasible mitigation program to address the impacts on trees of high salinity irrigation water.

A final concern with the analysis of salinity impacts is that the IS/MND does not evaluate the effects on creeks and biological resources, such as federally protected species, resulting from runoff of high salinity irrigation water. Matadero Creek runs through the Stanford Research Park site and the creek supports habitat for federally listed species. The IS/MND should fully evaluate these impacts in order to provide the public and the City with a complete and accurate picture of the Project's effects on the environment due to increased salinity.

In sum, while Stanford fully supports the goal of reducing potable water use, this Project presents serious concerns in terms of its salinity impacts on trees and wildlife. The widespread death of redwood trees resulting from high salinity irrigation water would have a profound negative affect on the vitality and value of the Stanford Research Park, one of the nation's leading business parks. More importantly for CEQA purposes, the widespread loss of redwood trees would have a variety of significant environmental ramifications -- including severe aesthetic impacts resulting from the loss of valued urban canopy; significant effects on the City's natural biological environment; conflicts with land use plans and policies that call for the protection of trees; and reduced absorption of CO_2, thereby leading to increased contributions to global climate change.

B. The Aesthetic and Land Use Compatibility Impacts Resulting from the Booster Pump Station and Back-up Generator Warrant Further Evaluation in the IS/MND

The IS/MND states that the visual character of the Mayfield Soccer Fields would be maintained, based on the fact that the booster pump station would be constructed underground and any aboveground structures "would go through architectural review during the design phase of the project and would satisfy the requirements of the Architectural Review Board." IS/MND at p. 39. But the architectural review process would not occur until after the City has approved the Project. Any impacts from an aesthetic or land use compatibility perspective associated with above-ground structures at the Mayfield Soccer Fields (including a back-up generator as well as any above-ground facilities needed to provide security or access) should be evaluated now as part of the CEQA review for this Project, instead of being deferred to a future process following Project approval.

C. The IS/MND Should Clarify the Mitigation Measures for Impacts to Biological Resources

To address the Project's impacts on biological resources, the IS/MND relies on several mitigation measures that are deferred. For example, the IS/MND provides that if red-legged frogs or western pond turtles are identified, the appropriate resources agency (the U.S. Fish & Wildlife Agency or the California Department of Fish & Game) will be consulted to determine the extent of potential impacts and "to identify measures necessary to avoid, minimize, and mitigate these impacts, such as obtaining an incidental take permit (for CRLF) or developing an exclusion or relocation program." IS/MND at p. 57. It is not clear, however, what the mitigation measures will be and whether such measures (when they are developed) will be effective. Similarly, with respect to impacts on nesting birds, the IS/MND provides that if active nests are encountered, "species-specific measures shall be prepared by a qualified biologist, in coordination with the CDFG and other appropriate agencies." *Id.* Further, with respect to impacts on California clapper and black rails, the IS/MND states that upon the completion of surveys, "survey results shall be submitted to the USFWS and CDFG for a final decision on the possibility of doing work during the breeding season." *Id.* at p. 58. It would be helpful for the IS/MND to provide more specificity on the biological mitigation that would be implemented.

D. Conclusion

Stanford recognizes the challenges that our community faces in securing an adequate water supply and the critical importance of water conservation for our community's future. Stanford is committed to water-saving practices and infrastructure throughout its planning and operations. This particular Project, however, raises several concerns that warrant a more thorough evaluation, so that the public and the City can make an informed evaluation of the Project's adverse impacts on the environment, as compared to its benefits.

We appreciate your consideration of these comments. Please feel free to contact us if you have any questions.

Sincerely yours,

William T. Phillips /gs

William T. Phillips
Senior Associate Vice President

Jim Inglis
Director of Design & Construction

Attachments

Jim Inglis

From: Nelda Matheny [Nelda@hortscience.com]
Sent: Friday, April 17, 2009 8:13 AM
To: Jim Inglis
Subject: recycled water

Hi Jim,
I'm only in the office for a few minutes, so I haven't had time to put much together for you. Attached is a short manuscript about some of the issues with using recycled water in landscapes.

As I mentioned on the phone, my experience with redwoods is that they are very sensitive to salts and usually begin to show toxicity symptoms within one to two years of its application. Redwoods must be irrigated frequently because they have no drought tolerance. Each irrigation adds salt, and over time the salts in the soil accumulate to damaging concentrations. I have observed mature redwoods significantly damaged after 3 years of irrigation with recycled water.

I do not think that is it possible to maintain healthy redwoods with recycled water containing high concentrations of sodium and chloride using conventional techniques and water-conserving irrigation schedules. It may be possible with adjustments to management practices such as leaching, abundant irrigation, and application of amendments to help leach salts. These modifications have yet to be tested in field applications.

As for coast live oak, it is quite tolerant of salt. Coast live oak can be maintained in a healthy condition when irrigated with recycled water. In general, drought tolerant species that require only infrequent irrigation are well suited for recycled water.

Feel free to share this information and my opinions with others.

Nelda

Nelda Matheny
HortScience, Inc.
2150 Rheem Dr., Suite A, Pleasanton CA
925 484 0211

DESIGNING LANDSCAPES USING RECYCLED WATER

by Nelda Matheny and James R. Clark

HortScience, Inc.
2150 Rheem Dr., Suite A
Pleasanton CA 84588
925 484 0211

Use of recycled water for landscape irrigation is increasing as supplies of potable water become limited. Recycled water can be an abundant source of inexpensive water or in some cases, the only source available for irrigation. Recycled water usually contains higher concentrations of some salts than potable (drinking) water. The maximum concentration of the salts is regulated by the state. However, those regulations are aimed at human and wildlife tolerances, not plant tolerances. Some plants are more sensitive to salts than animals and may be damaged when irrigated with water containing moderate to high salts.

Assessing recycled water quality

Water may contain ions or salts that are toxic to certain plants. While good quality water is suitable for use for irrigation of most any plant, poor quality water may inhibit plant growth or reduce health. For recycled water, the quality depends on the components of the water entering the treatment path, as well as the type of use before treatment. For instance, recycled water from municipal sources in which water softeners are used has a higher level of sodium than the water entering the system. During sewage treatment many of the inorganic compounds including salts and heavy metals are retained. Salts can be removed from recycled water through the process of reverse osmosis, although that is an advanced treatment that is not normally performed for water used in landscape irrigation.

The quality of a given recycled water source may vary through the year. In California, the quality of recycled water usually is better during the rainy season (winter) than during the periods of summer and fall drought. Water quality data may be requested from the treatment facility, or sample may be collected and analyzed by a laboratory. When requesting water quality data from the treatment facility ask for the range in measurements in addition to the annual averages normally reported. Water quality reports usually emphasize constituents of concern for human health. In some cases additional testing may need to be performed.

In the context of landscape irrigation, water quality refers to the presence and concentration of: total salts (TDS, Ec_w) as well as several specific ions (Cl, Na, B), bicarbonate, pH, trace elements and nutrients (N, P, K) (Table 1). Guidelines for interpreting water quality data are provided in Table 2.

[1] Adapted from Matheny, N., and J. R. Clark. 1998. Managing landscape using recycled water. In: *The Landscape Below Ground II*. D. Neely and G. Watson, ed. International Society of Arboriculture. Champaign IL.

Table 1: Constituents of recycled water that affect landscape plants and soils
(After Pettigrove and Asano 1985)

Constituent	Measured Parameter	Reason for Concern
Dissolved inorganics	Total dissolved solids (TDS); electrical conductivity (Ecw); specific elements (Na, Ca, Mg, Cl, B)	Excessive salinity may damage some plants. Specific ions such as chloride, sodium, boron are toxic to some plants. Sodium may pose soil permeability problems.
Hydrogen ion activity	pH	The pH of water affects metal solubility (e.g. Fe, Mn, Zn, Al) as well as alkalinity of soils.
Heavy metals	Specific elements (e.g. Cd, Zn, Ni, Hg)	Some heavy metals accumulated in the environment and are toxic to plants. Primary concern is for plants with high levels that are ingested by animals.
Nutrients	Nitrogen, phosphorus, potassium	N, P and K are essential nutrients for plant growth, and their presence normally enhances the value of water for irrigation. When discharged into the aquatic environment, N and P can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, N can lead to the pollution of groundwater.
Residual chlorine	Free and combined chlorine.	Excessive amounts of free available Cl (.0.05 mg/L Cl_2) may cause leaf-tip burn and damage sensitive plants. However, most chlorine in recycled water is in a combined form, which does not cause plant damage.
Suspended solids	Suspended solids	Excessive amounts of suspended solids cause plugging in irrigation systems.

Table 2: Interpretive guidelines for water quality for landscape irrigation. Species vary in tolerance to water quality. The poorer the water, the more severe are restrictions on species use. (After Pettygrove and Asano, 1985)

Parameter	Water quality for landscape irrigation		
	Good	Fair	Poor
Salinity			
TDS, mg/l	<450	450-2000	>2000
EC_w, dS/m or mmho/cm	<0.7	0.7-3.0	>3.0
Permeability[a]			
SAR	6	6-9	>9
Specific ion toxicity[b]			
Boron (B) (mg/l)	<0.5	0.5-1.0	>1.0
Chloride (Cl)			
Surface irrigation (mg/l)	<140	140-350	>350
Sprinkler irrigation (mg/l)	<100	>100	
Sodium			
Surface irrigation (SAR)	<3	3-9	>9
Sprinkler irrigation (mg/l)	<70	>70	
Miscellaneous effects			
Nitrogen (Total-N, mg/l)	<5	5-30	>30
Bicarbonate (HCO3)			
Sprinkler irrigation	<90	90-500	>500
pH		Normal range 6.5-8.4	
Residual chlorine			
Sprinkler irrigation (mg/l)	<1.0	1.0-5.0	>5.0

[a] Permeability affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together. At a given SAR, infiltration rate increases as salinity (EC_w) increases.
[b] Plant sensitivity to specific ions varies widely.

Total salts. Salinity is the most important measure of water quality for landscape plants. It is expressed as total dissolved solids (TDS) and electrical conductivity (EC_w). When water is applied to soils, some of the salts in the water (notably Na, Cl and B) remain in the soil. As these salts accumulate in the soil, plant toxicity may occur. Salt toxicity is first expressed as stunting of growth and yellowing of foliage. Burning of the edge of the leaves and defoliation usually follows. In severe cases, plants are killed. The degree of the problem depends on the sensitivity of the plant to salts and the concentration of the accumulated salts in the soil.

Specific ion toxicity. While salinity expresses the total salt content, it will not adequately identify potential toxicities from specific ions. Chloride (Cl), sodium (Na) and boron (B) concentrations in recycled water can and often do cause injury to sensitive plants. Boron in particular must be evaluated independently of other salts. It is toxic in such low concentrations (<1 ppm), that its presence will not be reflected in the general salinity measurement.

Sodium and chloride concentrations are particularly important if irrigation will be supplied by sprinkler. Plants will absorb both ions through their foliage. Toxicity through foliar absorption will occur at much lower concentrations than through soil absorption, particularly under high evapotranspiration conditions.

The toxicity symptoms of the specific ions are often difficult to distinguish from each other. Leaf chlorosis and marginal burning are typical. Necrosis associated with boron is often black in color and may appear as small spots near the leaf margin. As with salinity, plant tolerance to individual ions is highly species-specific. Some plants, like Indian hawthorn (*Raphiolepis indica*), can tolerate boron in excess of 7 ppm. Others like photinia (*Photinia* x *Fraseri*) are injured at 0.5 ppm. Furthermore, a plant may be relatively tolerant of boron, but highly sensitive to chloride. Little information is available to help develop lists of sensitivity of plants to specific ions. The landscape manager must rely primarily on experience and observation.

Sodium adsorption ratio. In addition to affecting plants directly, sodium can have negative effects on soil structure. It may cause dispersion of soil aggregates if present in high concentrations. This decreases both drainage and soil aeration which may cause plant decline and death. Soils high in clay are particularly susceptible to breakdown of aggregates by sodium.

Sodium hazard to soils is usually assessed from the sodium adsorption ratio (SAR), a value calculated from the sodium, calcium and magnesium concentrations. However, the permeability problems that can be caused by a high SAR can be partially offset by salts in the water. A more accurate measure of potential problems in irrigation water is the adjusted sodium adsorption ratio (adj R_{Na}) calculated from the salinity, bicarbonate, calcium, sodium and magnesium concentrations of the water.

Bicarbonate. Bicarbonate affects plants through its influence on pH and interaction with sodium. High bicarbonate can cause iron chlorosis symptoms in plants. Water high in bicarbonate, carbonate and calcium and/or magnesium can result in a white precipitate forming on foliage under sprinkler irrigation. Irrigation hardware is also susceptible to damage from bicarbonates. The precipitates can clog drip emitters.

When bicarbonate combines with calcium or magnesium in soils, calcium carbonate and magnesium carbonate precipitate out. Consequently the SAR of the soil increases, and permeability to water may become a problem. The bicarbonate hazard to soils can be evaluated by calculating the residual sodium carbonate (RSC). The RSC is the sum of the carbonate and bicarbonate ions minus the sum of calcium and magnesium ions. Water with an RSC>2.5 meq/l can develop permeability problems.

Heavy metals. Heavy metals are rarely present in water in sufficient quantities to be directly toxic to plants. However, most metals become tied up in the soil and their concentrations increase over time. Water quality criteria take the accumulation of the elements with many years of irrigation into account, and provide maximum concentrations with long-term use in mind. Effluent derived from domestic sources does not usually have problems with trace elements.

Nutrients. One of the advantages of using recycled water for landscape irrigation is that it contains plant nutrients and reduces the needs for application of fertilizer. Nitrogen (NH_4, NO_3), phosphorus (P_2O_5) and sulfur (SO_4) are the constituents of greatest benefit. Their concentrations are considered when evaluating recycled water to determine fertilization needs (Harivandi, 1988). Recycled water usually contains most of the micronutrients needed by plants. A negative aspect of this fertility involves storage of recycled water. Ponded nutrient-laden water develops algae and other aquatic weed problems more rapidly that potable water.

Designing and managing landscapes irrigated with recycled water

The potential problems to plants and soils can be minimized in a variety of ways, including both management and design. All of the management techniques require monitoring soil chemical and moisture characteristics, as well as plant responses. The main concerns are salinity and pH.. In addition, monitor water quality regularly because constituents can vary seasonally.

When designing new landscapes that will be irrigated with recycled water consider the following in the design:

1. Determine what the salt content of the recycled water will be. Check with the recycled water provider for a water analysis to determine concentrations of sodium, boron, and chloride. You may be able to access this information on the water agency's web site.

2. Avoid using salt-sensitive species. A list of species often damaged when irrigated with recycled water is provided in Table 3. If salt sensitive plantings cannot be avoided, irrigate on separate systems providing potable water.

3. Identify and solve drainage problems prior to planting. Good drainage is essential to using recycled water. Adjusting finish grades, eliminating hardpans and improving soil structure are methods to improve drainage.

4. Evaluate soil characteristics before planting. Soils should be tested for chemical and physical characteristics prior to planting to evaluate their suitability for irrigation with recycled water. Unfavorable conditions such as high sodium or chloride should be treated before planting to the extent possible.

When managing sites irrigated with recycled water, consider the following:

1. Minimize salt accumulation in the root zone. Minimizing salt accumulation is important to both avoid leaf burn and to avoid salt stress that can predispose plants to other problems. It is accomplished by leaching with heavy irrigations to flush accumulated salts below the roots. Annual rains may be adequate to maintain soil salinity within tolerable levels in some cases (heavy rainfall, well-drained soil). Where soils are heavier, leaching with good quality water may be needed during the growing season to lower salt levels.

Use of recycled water should be avoided in areas with poor drainage, since those areas cannot be leached.

2. Lower sodium concentrations in soils. If sodium concentrations become too high, drainage is impaired. Incorporating calcium (in the form of gypsum) into the soil and leaching can reclaim soil structure. Routine light applications of gypsum may be advantageous to avoid sodium problems.

3. Decrease fertilizer applications. Because recycled water contains significant amounts of nitrogen, phosphorus and potassium, applications of fertilizer can be reduced and in some instances, eliminated.

4. Increase irrigation frequency. Irrigation with recycled water should occur more frequently to dilute soil solutes, avoid water stress and minimize toxicity.

5. Moderate soil pH. Most plants tolerate a wide range in soil pH. As the pH of the soil begins to rise, however, acid-requiring plants may develop iron deficiency. Should chlorosis symptoms develop, the soil pH could be lowered by applying sulfur, or individual plants can be fertilized with iron to alleviate symptoms.

6. Monitor plant health. Additional stress factors caused by salts should be considered in the park's pest management program. Plant health must be monitored closely to identify stress-related problems that may develop. Some examples are bark beetles (*Ips*) on pines (*Pinus*), borers on alder (*Alnus*), and canker (*Seridium cardinale*) on cypress (*Cupressus macrocarpa*).

7. Monitor soil chemical changes. Soil conditions should be monitored through sampling programs to identify need leaching or other soil treatments. In most cases, soils should be sampled at the beginning and end of the irrigation period.

Recycled water can be an abundant, cost-effective source for irrigation. The landscape designers and managers should consider the quality of the water, soil chemical and physical conditions and sensitivity of landscape species to water constituents when planning and managing landscapes irrigated with recycled water.

Literature Cited

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Pettygrove, G. and T. Asano. 1985. Irrigation with Reclaimed Municipal Wastewater – A Guidance Manual. Lewis Publishers, Chelsea, MI.

Table 3: Landscape species prone to damage when irrigated with water having moderate to high salt concentrations.

Scientific name	Common name
Acer japonica	Japanese maple
Alnus rhombifolia	White alder
Alnus cordata	Italian alder
Betula pendula	European white birch
Camelia jamponica	Camelia
Celtis sinensis	Chinese hackberry
Cinnamomun camphora	Camphor
Citrus spp.	Orange, lemon
Clivia miniata	Clivia
Clytostoma callistegioides	Violet trumpet vine
Cymbidium spp.	Orchid
Dicksonia antarctica	Tasmamian tree fern
Dietes iridioides	Fortnight lily
Eriobotrya japonica	Loquat
Escallonia x exoniensis 'Fradesii'	Escallonia
Eucalyptus ficifolia	Red-flowering gum
Eucalyptus nicolii	Peppermint gum
Eucalyptus sideroxylon	Red ironbark
Euryops pectinatus	Euryops
Fragaria chiloensis	False strawberry
Gardenia angusta	Gardenia
Geijera parviflora	Australian willow
Ginkgo biloba	Maidenhair tree
Howea fosteriana	Kentia palm
Hydrangea macrophylla	Hydrangea
Ilex cornuta 'Burfordii'	Burford holly
Lagerstroemia indica	Crape myrtle
Liquidambar styraciflua	Sweetgum
Liriope muscari	Big blue lily turf
Lophostemon conferta (Tristania)	Brisbane box
Magnolia grandiflora	Southern magnolia
Michelia champaca	Champaca
Morus alba	Mulberry
Musa spp.	Banana
Nandina domestica	Heavenly bamboo
Nephrolepis spp.	Sword fern
Philodendron	Philodendron
Phoenix robelenii	Pygmy date palm
Photinia fraseri	Photinia
Pinus thunbergii	Japanese black pine
Pinus torreyana	Torrey pine
Platanus x acerifolia	London plane
Podocarpus gracilior	Fern pine
Podocarpus henkelii	Long-leafed yellow wood
Podocarpus macrophyllus	Yew pine
Prunus cerasifera 'Atropururea'	Purple leafed plum
Prunus illicifolia lyonii	Catalina cherry
Quercus rubra	Red oak
Rhododendron sp.	Rhododendron
Rosa cultivars	Rose

Table 3: Landscape species prone to damage when irrigated with water having moderate to high salt concentrations, continued.

Scientific name	Common name
Sequoia sempervirens	Coast redwood
Sarcococca ruscifolia	Sweet box
Spathodea campanulata	African tulip tree
Sophora japonica	Japanese pagoda tree
Tabebuia sp.	Trumpet tree
Tibouchina urvilleana	Princess flower
Tilia cordata	Little-leaf linden
Viburnum tinus	Viburnum
Wisteria sinensis	Wisteria
Xylosma congestum	Xylosma
Zamia furfuracea	Cardboard palm
Zelkova serrata	Zelkova

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Appendix D: Literature Review of Studies Related to Effects of Recycled Water on Landscapes

This appendix summarizes investigations that either relate to or were previously prepared specifically for the proposed Project. Most of these studies were conducted several years ago and are thus based on recycled water quality with total dissolved solids (TDS) at much higher levels than would be anticipated for the implementation of the proposed Project. Findings of these studies are thus not directly applicable to the potential impacts of the proposed Project. However, a summary is included as they were considered as part of the analysis.

Evaluation of Use of Recycled Water on Redwoods in the Mountain View/Moffett Area (2005)

HortScience conducted an independent study for the City of Palo Alto RWQCP to evaluate the effects of the RWQCP's recycled water on redwood trees in the Mountain View/Moffett area. The study evaluated redwood trees at five sites based on the factors identified below (2005)[1]:

- Water quality: In general, the poorer quality the water, the more likely plants will be injured;
- Salt-sensitivity of plants in the landscape: Plants vary widely in their tolerance to salts. Salt-and boron-sensitive plants have less tolerance to use of recycled water than do more salt tolerant species.
- Soil characteristics: Soil holds the water and elements for uptake by plant roots. Some constituents in recycled water can have negative effects on the soil as they concentrate over time. Three soil characteristics are of key importance including: chemical attributes of the soils (concentration of salts and existing pH), texture of the soil (fine [clay] vs. coarse [sandy soils]) and drainage characteristics (whether salts can be leached).
- Irrigation method: Plants are more sensitive to sodium and chloride toxicity when the water is applied to the foliage as opposed to the soil.

RWQCP water quality used in the analysis to determine the response of redwood trees to recycled water was based on the water quality in 2003. At that time, the maximum TDS concentration was 950 mg/L and the average TDS concentration (based on quarterly measurements) was 912 mg/L. The water quality was determined to range from good to fair for most parameters (TDS, ECw[2], boron, sodium adsorption ratio [SAR][3], nitrogen [N], carbonate and pH) but poor for chloride and sodium if sprinklers are used. Soil investigations at five locations (east of Highway 101 primarily in the vicinity of Amphitheatre Parkway) showed that the physical soil texture varied from loam to clay, but most soils were clay loam and appeared to be native bay mud overlain with variable imported fill soils. Chemically, the soils were similar.

The study found that "the response of an existing landscape to irrigation with recycled water depends on the degree to which soil will become affected and the tolerance of plant materials to salts and specific ions". At the time of the study, there had been no focused research quantifying the salt sensitivity of redwood trees, but HortScience had observed redwood decline at several sites in the South Bay that

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[1] HortScience. 2005. Evaluation of Use of Recycled Water on Redwoods in the Mountain View/Moffett Area. January.

[2] Electrical conductivity (EC) is a measurement of the ability of a solution to conduct electricity and is directly related to the concentration of dissolved salts. ECw is the electrical conductivity of the water.

[3] SAR is a water quality measurement and is a value calculated from sodium, calcium, and magnesium concentrations. It is calculated to determine the sodium hazard to soils, as sodium can affect directly soil structure by causing dispersion of soil aggregates, decreasing soil permeability to water and air, which may affect plant health. Adjusted SAR is a more accurate measure of potential problems in irrigation water and is calculated from the salinity, bicarbonate, calcium, sodium and magnesium concentrations of the water.

converted from potable to recycled water. However, there were also redwood trees at the same sites that exhibited few if any symptoms. The study also noted that "there have been increasing reports of decline in redwoods throughout California in landscapes irrigated with both potable and recycled water." The reports states that "[t]he work to date has not fully answered why redwoods have been affected while other landscape species and some redwoods were largely unaffected. There appeared to be relationships among soil moisture, rooting depth, and tree condition. Trees in good condition were in better-watered sites and had deeper roots than trees in poor condition. This suggests that irrigation management is an important contributing factor. Soil texture and structure are also likely important because of their effects on water movement through the soils and root development".

The study also found that there are other factors that can cause decline in redwood trees. Existing and potential problems with redwood trees independent of irrigation water quality and the factors described above (HortScience Inc. 2005) include the following:

- Climatic factors: Redwood trees are native to cool, foggy coastal areas in forest situations where the conditions differ drastically from those typical of the Bay Area landscape. Rather than moisture in the air and soil, redwood trees planted in Bay Area landscapes experience prolonged periods of warm, dry weather, low rainfall and infrequent fog. Redwoods are also typically planted in turf or surrounded by pavement rather than the leaf litter that shades and insulates the roots in forest areas. These conditions promote physiological stress.
- Fungal pathogens: For example, Cylindrocarpon found in redwoods in the South Bay is known to cause root rot, although none have been reported as exclusive redwood pathogens.
- Other diseases: Other diseases that have caused decline in redwood trees include Botryosphaeria canker, Phytophthora root rot, and Armillaria root rot. In addition, the insect pest, *Aspidotus nerri*, may contribute to redwood tree decline.

HortScience concluded that while redwood trees are sensitive to salts and irrigation with recycled water has been linked to plant damage, "there are existing and potential problems with redwoods that are independent of irrigation water quality." Thus, it was determined that recycled water may be used for landscape irrigation in the Mountain View/Moffett area as long as site management and possibly water quality adjustments are implemented.

<u>Palo Alto RWQCP – Recycled Water/Redwood Tree Monitoring Program (2009 to 2014)</u>

HortScience conducted monitoring of landscapes in the Mountain View Shoreline area to determine the effects of irrigation with recycled water[4]. Six to eleven monitoring sites were inspected as part of the Recycled Water / Redwood Tree Monitoring Program from June 2009 through summer 2014, of which three sites were used as control sites (redwood trees were irrigated with potable water only). Sites receiving recycled water were converted from potable water irrigation to recycled water irrigation between January and March 2010. Results for more recent monitoring events are summarized in **Table D-1**, which characterizes the changes that have occurred over time. By the summer of 2014, most of the redwood trees irrigated with recycled water were showing foliar necrosis symptoms and development of epicormic shoots that are typical of salt damage on redwoods. Factors that have contributed to the decline of the redwood trees in general over the years include higher salt concentrations in the recycled water, soil characteristics, insufficient soil moisture, and the current drought, which has reduced rainfall that would normally occur in the winter and spring season to supplement irrigation and flush the salts from the upper layers of the soils. The current drought, in addition to the other conditions specified above, have contributed to the decline in health of redwood trees that have been irrigated with recycled water.

[4] HortScience. Recycled Water/Redwood Tree Monitoring Program, Palo Alto RWQCP. Results of Site Monitoring for Spring 2009 through Summer 2014.

Table D-1: RWQCP Recycled Water/Redwood Tree Monitoring Program Monitoring Results

Parameter	Results of Monitoring			
	2009 through Spring 2011	2009 through April 2013	2009 through April 2014	2009 through Summer 2014
Visual Analyses	The spring 2011 results showed that the visual appearance of the redwood trees remained normal and exhibited signs of good health and vigor.	The redwood trees have remained normal in appearance and exhibited signs of good health and vigor except at three sites, where appearance declined from good to fair. The change in condition is thought to be due to a combination of salt and water stress. No foliage symptoms of sodium or chloride toxicity have been noted to date.	The redwood trees that have been irrigated with recycled water are beginning to show foliar necrosis symptoms that are typical of salt damage. Trees that have been well irrigated (two sites) are in better condition than trees that have not (two sites)	Most of the redwood trees irrigated with recycled water were showing foliar necrosis symptoms and development of epicormic shoots that are typical of salt damage on redwoods.
Soil Analyses	Soil analyses showed that soil salinity increased at some sites and decreased at other sites but that total salinity and chlorides were higher in deeper soil samples than surface samples (suggesting that salts were leached lower in the soil profile during the winter rainy season); soil conditions remained acceptable for landscaped plants, including redwood trees.	In general, soil pH has remained stable over the study period. SAR, salinity and specific ions (ECe, sodium, chloride) gradually increased and were above recommended thresholds for redwoods in sites irrigated with recycled water. Sites irrigated with potable water did not have elevated concentrations of salts.	In general, soil pH has remained stable over the study period. SAR and salinity and specific ions (ECe, sodium, chloride) gradually increased and were above recommended thresholds for redwoods in sites irrigated with recycled water. Sites irrigated with potable water did not have elevated concentrations of salts.	In general, SAR, salinity (ECe) and specific ions (sodium, chloride) were above recommended thresholds for redwoods in sites irrigated with recycled water. Sites irrigated with potable water did not have elevated concentrations of salts. Soil chloride concentrations dropped below threshold levels at two sites, although sodium and electrical conductivity increased. Reductions in chloride were presumably due to efforts to leach the soil. Plant appearance declined slightly. SAR was above the threshold at four sites. Gypsum should be applied during the winter to reduce concentrations of sodium.

Parameter	Results of Monitoring			
	2009 through Spring 2011	2009 through April 2013	2009 through April 2014	2009 through Summer 2014
Tissue Analysis	Sodium and chlorine concentrations in foliage samples were generally similar at all sites and were within the acceptable range for redwood trees.	In general, tissue chloride and sodium concentrations where higher at sites irrigated with recycled water than sites irrigated with potable water. The highest tissue chloride concentrations were at two recycled water sites. However, no visual symptoms of chloride toxicity were noted.	Chloride and sodium concentrations in redwood foliage where higher at sites irrigated with recycled water than sites irrigated with potable water. The highest tissue chloride concentrations were at two recycled water sites.	Chloride and sodium concentrations in redwood foliage were higher at sites irrigated with recycled water than sites irrigated with potable water. Tissue chloride and sodium concentrations at recycled water sites continued to increase, and exceeded thresholds except at one site.
Soil Moisture	Soil moisture ranged from dry to slightly moist depending on the site.	Soil moisture data has shown that soils at most of the monitoring sites were drier than optimum for redwoods except at three sites. Data also indicated that irrigation during the fall and early spring is needed when rainfall is inadequate. Supplementing winter rainfall could improve leaching of salts in the soil profile in sites irrigated with recycled water.	Soil moisture data has shown that soils at most of the monitoring sites were drier than optimum for redwoods except at two sites. Data also indicated that irrigation during the fall and early spring is needed when rainfall is inadequate. Supplementing winter rainfall could improve leaching of salts in the soil profile in sites irrigated with recycled water, especially during low rainfall years.	Cumulative soil moisture data between April and August showed that soils at most of the monitoring sites were drier than optimum for redwoods except at two sites.

Parameter	Results of Monitoring			
	2009 through Spring 2011	2009 through April 2013	2009 through April 2014	2009 through Summer 2014
Gypsum Application	Not Applicable.	Three gypsum applications to the soil in early 2012 at three sites helped reduce the soil SAR by the April 2012. The SAR at one site increased in 6 months' time (April to October 2012). Annual applications of gypsum during the winter are advisable.	Three gypsum applications to the soil in early 2012 and 2014 at three recycled water sites helped reduce the soil SAR. Annual applications of gypsum during the winter are advisable.	Not Applicable

Solutions Project Report (2009)

In 2005, the Santa Clara Valley Water District (SCVWD) engaged researchers from the University of California to investigate water quality requirements for protection of soil and plants, and propose water quality and management practices that would enable sustainable use of recycled water for landscape irrigation throughout Santa Clara County. Three studies were conducted as part of the SCVWD-funded research effort, and the findings were released at a workshop on February 17, 2009 and included in the Solutions Project Report[5]. These studies included the following:

- Irrigation with Recycled Water in Santa Clara County: Limitations and Potentials, J.D. Oster, PhD
- Determining the Tolerance of Coast Redwood, *Sequoia Sempervierens* 'Aptos Blue' to Sodium and Chloride, Corey S. Barnes, Dr. Lorence R. Oki, and Dr. Richard Y. Evans
- Evaluation of Local Soils for Susceptibility to Structural Degradation from Irrigation – Jocelyn Marie Beaudette, Revised by M.J. Singer

The major findings were as follows (Oster 2009):

- Coast redwoods are sensitive to total soil-water salinity independent of the type of salt causing the salinity. The goal of sustainable water management for redwoods would be to maintain soil-water salinity levels in the root zone between 1 and 2 decisiemen/meter (dS/m[6]) and to allow levels to approach 3 dS/m with caution and intensive monitoring of both the soil and the leaf burn of redwood trees.
- Long-term, sustainable irrigation of redwoods with waters that have salinity levels of 1 dS/m may be possible. However, considerable excess water over that consumed by the plants will need to be applied, and all of it must infiltrate into the soil to prevent soil-water levels exceeding 2 to 3 dS/m.
- Careful water management will be required (e.g., application of water based on measured evapotranspiration and the crop coefficient method of the California Irrigation Management Information system [CIMIS], apply water beneath the tree canopy, monitor the soil water content in the root zone, apply sufficient water to maintain soil water contents at targeted levels, periodically adjust the crop coefficient so that the targeted soil water contents are achieved)
- As needed, application of gypsum to increase salinity and reduce sodium levels in the soil, which would improve infiltration rates. However, gypsum will increase soil salinity[7] so it should be used sparingly and applied before the rainy season to be most effective.
- With even the best management, excess salinities may not be preventable. In such a case, either reduce the salinity of the applied water, or remove the diseased redwood trees.

Oster collected salinity and sodicity levels from three sites (the Shoreline Golf Links in Mountain View, Villages Golf and Country Club in San Jose, and Wilson School in Santa Clara) in August 2007 and used that data and findings of the other investigators to provide recommendations for the water quality requirements and management practices at these locations (Oster 2009). The findings are as follows:

- Shoreline Golf Links overlie a clay-capped and sealed landfill, and the landscape was irrigated with potable supplies. Oster indicated that under then current conditions, the area was under irrigated and more infiltration was necessary (with the need for a drainage system to remove the

[5] Santa Clara Valley Water District, the City of Mountain View and the South Bay Water Recycling. 2009. Solutions Project Report. This report consists of three studies conducted by J.D. Oster; Corey S. Barnes, Dr. Lorence R. Oki, Dr. Richard Y. Evans; and Jocelyn Marie Beaudette.
[6] A dS/m is a measure of electrical conductivity, and approximates to 640 mg/L TDS.
[7] All sources of salt are equally effective in causing leaf burn of redwood leaves and in reducing growth.

excess water needed to control soil salinity). Oster also recommended certain site management adjustments that also needed to be made. Oster did not recommend changing the water source at this site to recycled water given the existing conditions.

- Village Golf Course was irrigated with South Bay recycled water between 2001 and 2007, with some periods in 2004-2005 and 2007 when potable water was used. Oster found that the existing leaching fractions[8] at the time of sampling in 2007 posed no salinity hazard for turf but a hazard for coastal redwood trees. Oster recommended the use of recycled water with an EC no greater than 1.0 dS/m and specific leaching fractions that must be achieved at this site during the summer in areas beneath the tree canopy.
- Wilson School was irrigated with recycled water. Because the only source of water for the trees during the summer was the water applied to the grass Oster determined that it was unlikely that the trees could survive under this situation (under irrigation does not typically pose a problem for turf). Thus, Oster recommended a separate irrigation system for the trees and suggested that the EC of the applied water should be no more than 1.0 dS/m with a specific target leaching fraction achieved during the summer in areas beneath the tree canopy.

In their study of the tolerance of coast redwood to sodium and chloride, Barnes et al. (2007) conducted a greenhouse study to quantify the response of coast redwood to these two ions. Specifically the objectives of the study were to quantify growth retardation and leaf ion accumulation, and to record the development of leaf burn symptoms in response to a set of salinity treatments composed of several salt concentrations and compositions. Barnes et al. found that the response of the coast redwood under greenhouse conditions indicated "a clear increase in detrimental effect with increasing treatment concentration", and that "the effects of the salinity treatments on the redwood trees were more related to total salinity rather than to specific ion effects". The following is summarized by Oster regarding the Barnes et al. study:

> "Based on the findings reported by Barnes et al. (2007) for redwoods, an average ECsw[9] greater than about 1.3 dS/m resulted in reduced trunk growth and an average ECsw of 3.6 dS/m resulted in leaf burn for all treatments. To prevent leaf burn, a major quality factor for ornamentals, the target average ECsw in the rootzone needs to be somewhere between 2 and 3 dS/m. For Palo Alto recycled water, the most saline recycled water, the leaching fractions required to obtain these average ECsw values range from 0.25 to greater than 0.4. If redwood response to ECsw depends more on the average ECsw in the upper portion of the rootzone, than the average ECsw for the whole rootzone, then the corresponding target range of leaching fraction for Palo Alto water ranges from < 0.05 to 0.24."

In addition, Barnes et al. concluded that if proper leaching is not employed to carry the salts out of the root zone, "even at relatively low conductivity of 1.0 dS/m, salt can accumulate in the soil profile if proper leaching is not employed to carry the salts out of the root zone." In addition, "it is clear that redwoods can tolerate EC values in the range typical for recycled waters if irrigation is properly managed."

Beaudette and Singer (2007) evaluated a subset of Santa Clara County soils for susceptibility to structural degradation from irrigation. Under laboratory conditions, they evaluated 30 soil samples (from sites that

[8] Leaching fraction (LF) is the amount of water that moves downward within and below the root zone, divided by the amount of applied water. LF can be estimated by calculating ECsw and dividing it into the EC of the irrigation water.
[9] ECsw is the electrical conductivity in the soil water.

were chosen to maximize variation in soil physical and chemical characteristics[10]) "to determine the effects of different sodium concentrations (measured as SAR) and different water quality (measured as EC) on the rate of water movement through the soils. Saturated hydraulic conductivity (Ksat)[11] and flow rates were used as measures of treatment effect." They found that the salinities of the percolating solutions had a larger impact on Ksat for a given soil than did the SAR of the percolating solutions[12]. "Fluid movement through the soils decreases as EC of the leaching solution decreases. In addition, "soils that were the most sensitive to low EC solutions had the lowest sand content and highest CEC [cation exchange capacity]. Soils that were the least sensitive to low EC solutions had the highest sand content and lowest CEC." In other words, soils with higher silt and clay content are more affected by water quality than other soils. Beaudette and Singer also indicated the following:

> "Use of treated effluent with SAR of 5 or more will surely, over time, add sodium to the soil exchange complex. To maintain soil structure, infiltration rate, and percolation rate of soils with accumulated salts, careful site specific management will need to be employed. One option for managing the sodium and EC is to apply gypsum. Gypsum, along with sufficient leaching water, will help to remove sodium from the soil and will maintain the EC so that soil structure is preserved. Gypsum applied during the irrigation season after salt build up begins will have the greatest effect. Continued careful water management, with additional water added to leach salts is necessary to maintain structure and keep soil hydrology optimum."

Recycled Water Guidelines for Stanford Research Park (2009)

HortScience and David Kelley and Associates prepared recycled water quality guidelines for Stanford Research Park[13] for Stanford University. This report reiterated the factors that must be considered in evaluating site suitability for irrigation with recycled water, similar to those discussed for the Mountain View evaluation done in 2005. This memorandum also included an additional soil characteristic that contributes to suitability of the site. Specifically, the soil profile, or the vertical gradation or layering with soil depth affects water percolation, salt accumulation and plant rooting patterns. The report also included guidance on site evaluation prior to applying recycled water to a landscape, and water quality guidelines. The report identified four categories of water quality based on the tolerance of the plant materials to salts in the water source and degree to which soil is expected to become degraded, as shown in **Table D-2** below:

[10] These sites were taken from Mountain View and areas further south. None of these sites are located in the City of Palo Alto.
[11] Saturated hydraulic conductivity, K_{sat}, describes water movement through saturated media.
[12] According to Dr. Oster, the higher the sodium content of irrigation water, the higher the SAR of the soil water (SARsw) in the soil irrigated with that water, and the greater the likelihood soil particles will adsorb water and separate. When soil particles separate, the smaller soil particles can plug the large soil pores through which most of the water flows. This reduces the rate water can move into and through soils.
[13] This study was originally prepared on May 27, 2009 and included in Stanford University's letter on May 28, 2009, but was updated in November 2009.

Table D-2: Water Quality Categories Appropriate to Sustain Healthy Landscapes as Affected by Soil Texture, Drainage, and Plant Sensitivity to Salts.

Soil Texture/Drainage	Plant Sensitivity to Plants		
	Sensitive	Moderate	Tolerant
Sandy, good drainage	Category 1 or 2	Category 1,2,3	Category 1,2,3,4
Loam, good to moderately drained	Category 1 or 2	Category 1,2,3	Category 1,2,3,4
Clay or poor drainage	Category 1	Category 1 or 2	Category 1,2, 3

Note: The categories are defined as follows: Category 1: Good water quality with no restrictions on site use; Category 2: Moderate water quality that is appropriate for all landscapes except those with salt and/or boron sensitive plants and poorly drained soils that cannot be leached; Category 3: Fair water quality that can be used where plants have at least moderate salt and/or boron tolerance and soils are at least moderately drained; landscapes on poorly drained sites must be comprised of plants with good salt and/or boron tolerance; and Category 4: Poor water quality that is appropriate only for sites having salt and/or boron tolerant plants and moderate to good drainage.

The report provides interpretative guidelines for recycled water for landscape irrigation under the four categories. The TDS, chloride and sodium concentrations for a Category 1 source water are <650 mg/L, 100 mg/L and 70 mg/L, respectively. The concentrations of the same parameters for Category 2 source water are 650-1,000 mg/L, 100 – 200 mg/L, and 70-150 mg/L, respectively.

Finally, the report provides recommendations of the category of recycled water that should be used to irrigate Stanford Research Park based on the types of soil in the area:

> “Based on USDA Natural Resources Conservation Service soil survey maps and geotechnical reports prepared for several sites, we know that the soils at SRP are layered, with variable clayey fills present. Native soil textures range from clays and gravelly clays to clayey and silty sands and depths to bedrock vary. The soils were undoubtedly compacted during construction. From this information we estimate that the soils are at least moderately to somewhat poorly drained, with leaching potentials ranging from good to moderately poor.
>
> Given our current knowledge of soil conditions at Stanford Research Park, and the presence of significant trees having low salt tolerance, we recommend that recycled water meet Category 1.”

<u>Evaluation of Use of Recycled Water for Landscape Irrigation, Palo Alto Recycled Water Project (2011)</u>

In 2011, HortScience conducted an evaluation of the use of recycled water for landscaped irrigation for this Project[14] (see **Appendix G**). The study evaluated the potential response of landscapes to RWQCP recycled water, and involved the investigation of soil characteristics and description of plant species and their tolerance to salts at 13 sites (on 7 properties[15]). Predicted responses of these landscapes were based on the RWQCP water quality that was prevalent during the November 2008 to August 2010 period.

In evaluating the likely landscape responses to the recycled water, the study considered the maximum and mean concentrations of total salts, boron, sodium, chloride, bicarbonate, and the calculated value for

[14] HortScience. 2011. Evaluation of Use of Recycled Water for Landscaped Irrigation. Palo Alto Recycled Water Project Phase 3. June 13.
[15] Seven sites were selected based on the primary mapped soil units identified in the USDA Soil Conservation Service that also had a range of landscaped types.

adjusted sodium adsorption ratio (SAR_{adj})[16]. **Table D-3** presents the RWQCB recycled water analysis for the July 2007-June 2008 period.

Table D-3: RWQCB Recycled Water Analysis for July 2007-June 2008

Parameter	Minimum	Maximum	Mean	Salinity Hazard
TDS (mg/L)	870	1000	963	Slight
ECw (µmho/cm)	1518	1760	1656	Moderate
Boron (B, mg/L)	0.31	Al	0.35	None
Chloride (Cl, mg/L)	308	384	339	Moderate
Sodium (Na, mg/L)	170	240	211	Moderate
Sodium adsorption ratio	5.3	5.9	5.0	None
Alkalinity	85	196	114	None
Nitrate (NO3, mg/L)	19	26	23	None
pH	6.6	7.2	7.0	none

The study determined that the RWQCP recycled water at the mineral content shown in **Table D-3** presents a moderate salinity hazard for landscape irrigation. Boron, pH, and SAR are not limiting to landscapes. It is expected that there would be gradual increase in soil salinity (TDS, sodium and chloride) and damage is likely to occur in sensitive plant species and may occur to moderately tolerant species where salts accumulate in the soil over several years of irrigation. SAR is expected to gradually increase, with the potential to decrease the soil permeability with prolonged use.

The investigation found that soils at the study sites are variable in texture and structure and across the various landforms they occupy, and thus not possible to characterize uniformly. Some soils contained high clay content, compacted horizons, which "complicate prescriptive irrigation and nutrient delivery systems. In a system where leaching is necessary and water throughflow is desirable (as in this case, where salt content of the irrigation waters and native soils is problematic), the recognition of these complications is a prerequisite for irrigation planning and management." Despite the varying soil characteristics, the study found that "chemical composition of the soils with regards to salts (Ec_e, Cl, Na, B, SAR) was similar among the 26 soil samples analyzed. In all samples the salt concentrations were low and within the range of tolerance of salt sensitive plants."

With respect to salt sensitivity of landscaped plants, the results show that the majority of the plants at the studied sites had moderate to high tolerance for soil salinity. If considering only the principal plant taxa, those classified as the more common plants at multiple sites, the percentage of plants with high to moderate salt tolerance increases, as shown in **Table D-4**.

[16] As bicarbonate and carbonate data were not available, adjusted SAR ratio or residual sodium carbonate was not calculated.

Table D-4: Salt Tolerance Rankings for Landscape Plants at Seven Properties

Site	No. Taxa	Salt Tolerance Rankings for Taxa			
		High	Moderate	Low	Unknown
Theranos	50	19	23	5	3
VM Ware	73	30	25	15	3
Clocktower	51	12	20	18	1
Mitchell Park	74	26	33	14	1
Terman Park	36	13	13	9	1
Hewlett Packard	84	33	29	17	5
Tesla Motors	38	17	16	5	0
Total, all taxa	227	80 (35%)	89 (39%)	47 (21%)	11 (5%)
Principal Plants	99	42 (42%)	35 (36%)	17 (17%)	5 (5%)

Note: annual plants excluded

The study showed that there are opportunities and constraints in using recycled water at the quality specified in **Table D-3** on the landscaped areas at the seven specific sites. Constraints include plants with low to moderate salt tolerance having the potential to develop salt damage when irrigated with RWQCP recycled water, salt accumulation on soils where extensive filling over clays has occurred, and certain site management issues (regarding the need to keep soils moist, conduct leaching as appropriate, monitor for pests, and increase maintenance, repair, and/or replacement of irrigation systems). Moderately salt tolerant plants would be more vulnerable where irrigation occurred on soils that are more susceptible to accumulating salts.

The study provided recommendations for the use of RWQCP recycled water (at the concentrations specified for 2007-2008) in the City with changes in landscape management to monitor and react to increases in soil salinity and by replacing low salt tolerant plants with species having high salt tolerance. It also recommended soil monitoring for salinity, a leaching program to maintain soil salinity (and apply gypsum prior to leaching) and modifying irrigation frequency to maintain the soil. The study also recommended performing an irrigation system audit to quantify application rates, modifying the irrigation systems to avoid wetting plant foliage, and consideration of soil moisture monitoring equipment to measure soil moisture at depths within and below plant root zones. Most importantly, the study indicated how the salinity hazard could be reduced or eliminated. Specifically, "[t]he salinity hazard could be eliminated if the recycled water quality was improved to maintain TDS below 650 mg/L, Ec_w below 1000 µmohs/cm, chloride below 100 mg/L, and sodium below 70 mg/L.

<u>Tree Inventory of Seven Properties in the Stanford Research Park Area, Palo Alto Recycled Water Project – Phase 3 (2011)</u>

As a follow up to the above investigation, HortScience conducted a tree inventory of the seven properties that would be provided recycled water under the proposed Project (see **Appendix H**).[17][18] The study provided a count of the number of trees by species, identification of all protected trees as identified in the City of Palo Alto Municipal Code, and the estimate of the tolerance of each species to recycled water

[17] HortScience. 2011. Tree Inventory of Seven Properties in the Stanford Research Park Area, Palo Alto Recycled Water Project, Phase 3. October 11.
[18] The City did not perform a tree inventory for all potential customer areas. However, the results of the HortScience tree inventory could represent the distribution and percentage of trees within the overall Project area.

based on the RWQCP water quality data presented in the earlier investigation, which assumed maximum and mean TDS concentrations of the recycled water at 1,000 and 963 mg/L, respectively. A total of 3,055 trees was identified within the seven properties, of which 2,609 (85%) were not protected and 446 (15%) were protected. Of the 3,055 trees, only 9% of those trees are protected and considered to have low salt tolerance. **Table D-5** summarizes the tree inventory conducted as part of this study. The percentages of salt-tolerant trees presented in the table are separated for non-protected and protected trees. For example, 58 of the 95 trees or 59% of trees that are non-protected at the Theranos property are considered to be highly salt-tolerant. According to the study, plants with high salt tolerance are expected to maintain good appearance and health using RWQCP recycled water. Those with moderate salt tolerance are expected to develop symptoms of salt stress when irrigated with RWQCP recycled water, especially in poorly drained soils. These plants may show some damage, but appearance will likely be acceptable when viewed from several feet away. Regular and thorough leaching would be required to maintain these plants. The plants with low salt tolerance would likely have foliage damage that degrades plant appearance, and leaching treatments using current recycled water would unlikely be adequate to prevent plant damage.

Table D-5: Trees at the Seven Properties, their Regulatory Status and Salt Tolerance

Site	# of taxa	Total # of Trees	Number of Trees							
			Non Protected[1]				Protected[1]			
			# Trees	High[2]	Mod[2]	Low[2]	# Trees	High[2]	Mod[2]	Low[2]
Theranos	15	99	95	58 (59%)[3]	28 (28%)	9 (9%)	4	4 (4%)	0 (0%)	0 (0%)
VMware	25	740	626	246 (33%)	188 (25%)	192 (26%)	114	7 (1%)	0 (0%)	107 (14%)
Clocktower	21	235	210	45 (19%)	68 (29%)	97 (41%)	25	0 (0%)	0 (0%)	25 (11%)
Mitchell Park	44	362	344	122 (34%)	134 (37%)	88 (24%)	18	1 (0%)	1 (0%)	16 (4%)
Terman Park	34	173	136	16 (9%)	50 (29%)	70 (40%)	37	13 (8%)	0 (0%)	24 (14%)
Hewlett Packard	46	911	770	230 (25%)	194 (21%)	346 (38%)	141	7 (1%)	40 (4%)	94 (10%)
Tesla Motors	26	535	428	308 (58%)	97 (18%)	23 (4%)	107	81 (15%)	26 (5%)	0 (0%)
Total, all sites	96+	3055	2609	1025	759	825	446	113	67	266
% of trees (protected vs. non-protected)			100%	39%	29%	32%	100%	25%	15%	60%
% of trees, all trees				34%	25%	27%		4%	2%	9%

Notes:
[1] Regulatory status of the trees is based on the definition defined in the City Palo Alto Municipal Code.
[2] Salt tolerance is characterized as high, moderate, and low.

[3] Percentages in parenthesis refer to the percentage of plants classified as high, moderate, and low within a particular site.

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Appendix E – Environmental Checklist

As described in Chapter 1, this Environmental Impact Report (EIR) focuses on those issues of primary concern identified during the 30-day scoping comment period for the Draft EIR (i.e., effects of recycled water use for irrigation of landscaped areas, the groundwater basin, and on the urban forest). The remaining issue areas are provided in this appendix, which presents the Initial Study checklist that was prepared to focus the EIR on effects that were considered to be potentially significant, and to identify those effects determined not to be significant[1]. The information presented below follows the California Environmental Quality Act (CEQA) Appendix G Environmental Checklist as adapted by the City of Palo Alto. The setting (baseline) are based on the time the Notice of Preparation was circulated (July 2011) but also updated as relevant to current conditions. Unless otherwise noted, the current conditions are similar to the conditions in 2011. An analysis of the impacts is based on a comparison of the anticipated physical changes to the environmental against the baseline conditions. Significance conclusions are based on the anticipated effects before the standard project requirements (proposed as part of the Project as specified in *Chapter 2, Project Description*) and mitigation measures have been implemented. Standard project requirements and/or mitigation measures, presented at the end of each resource topic discussion where relevant, would reduce potential impacts to less than significant. The sources of information for the analysis are provided in Chapter 5, References and List of Preparers and thus are left blank in the tables below.

E.1. AGRICULTURAL AND FOREST 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 Department 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 the forest carbon measurement methodology provided in the Forest Protocols adopted by the California Air Resources Board.

[1] Please see Chapter 3 for a discussion of Aesthetics and Hydrology and Water Quality. Please note that the Mandatory Findings of Significance that is typically in the Environmental Checklist is not included in this Appendix. Please see Section 4.3, Cumulative Effects and Section 4.5.1 regarding significant and unavoidable impacts of the Project in *Chapter 4, Other CEQA/NEPA Considerations* for a discussion of topics address by the Mandatory Findings of Significance.

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements /Mitigation Incorporated	Less Than Significant Impact	No Impact
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)[2]) or timberland (as defined in Public Resources Code section 4526[3])?					✓
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?					✓

SETTING

The Project area is located within an urban environment consisting of residential, commercial, and industrial uses (City of Palo Alto, 2007; City of Palo Alto, 2011). The Santa Clara County Important Farmland Map designates the Project area as "Urban and Built-up Land"[4] (CDC, 2011). The project does not contain any important farmlands, and no farming or agriculture takes place within the Project area. In addition, no forest lands or timberlands occur within the Project area.

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[2] PRC 12220(g): "Forest land" is land that can support 10-percent native tree cover of any species, including hardwoods, under natural conditions, and that allows for management of one or more forest resources, including timber, aesthetics, fish and wildlife, biodiversity, water quality, recreation, and other public benefits.

[3] PRC 4526: "Timberland" means land, other than land owned by the federal government and land designated by the board as experimental forest land, which is available for, and capable of, growing a crop of trees of any commercial species used to produce lumber and other forest products, including Christmas trees. Commercial species shall be determined by the board on a district basis after consultation with the district committees and others.

[4] According to the California Department of Conservation, "Urban and built-up land is occupied by structures with a building density of at least 1 unit to 1.5 acres, or approximately 6 structures to a 10-acre parcel. Common examples include residential, industrial, commercial, institutional facilities, cemeteries, airports, golf courses, sanitary landfills, sewage treatment, and water control structures."

DISCUSSION

a) **No Impact.** No agricultural lands or uses occur within the Project area. Thus, the proposed Project would not convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland) to non-agricultural use or affect agricultural practices. No mitigation is required or necessary.

b) **No Impact.** As no agricultural uses occur within the Project area, the proposed Project would not conflict with existing zoning for agricultural use or with a Williamson Act contract. No mitigation is required or necessary.

c) **No Impact.** The proposed Project would not conflict with existing zoning for, or cause rezoning of, forest land or timberland as none of these resources occur within the Project area. Thus, no impact would occur and no mitigation is required or necessary.

d) **No Impact.** As no forest land exists within the Project area, the proposed Project would not result in the loss of forest land or conversion of forest land to non-forest use. Thus, no impact would occur and no mitigation is required or necessary.

e) **No Impact.** As described above, no agricultural uses occur within the Project area. Therefore, the proposed Project would not involve changes in the existing environment, which, due to their location or nature, would result in the conversion of farmland or agricultural practices to non-agricultural use. No mitigation is required or necessary.

MITIGATION MEASURES:

No mitigation is required.

E.2. AIR QUALITY

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Conflict with or obstruct with implementation of the applicable air quality plan (1982 Bay Area Air Quality Plan & 2000 Clean Air Plan)?				✓	
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation indicated by the following:					
i. Direct and/or indirect operational emissions that exceed the Bay Area Air Quality Management District (BAAQMD) criteria air pollutants;			✓		
ii. Contribute to carbon monoxide (CO) concentrations exceeding the State 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 levels of toxic air contaminants?					
i. Probability of contracting cancer for the Maximally Exposed Individual (MEI) exceeds 10 in one million				✓	
ii. Ground-level concentrations of non-carcinogenic TACs would result in a hazard index greater than one (1) for the MEI				✓	
e) Create objectionable odors affecting a substantial number of people?				✓	
f) Not implement all applicable construction emission control measures recommended in the *Bay Area Air Quality Management District CEQA Guidelines?*					✓

SETTING

The BAAQMD is the regional air quality agency for the San Francisco Bay Area Air Basin (SFBAAB). The proposed Project is located in the Santa Clara Valley subregion of the air basin, which is bounded by the Bay to the north and by mountains to the east, south and west. The Santa Clara Valley has a high concentration of industry at the northern end, in the Silicon Valley. Some of these industries are sources of air toxics as well as criteria air pollutants. In addition, Santa Clara Valley's large population and many work-site destinations generate the highest mobile source emissions of any subregion in the SFBAAB. Thus, the air pollution potential of the Santa Clara Valley is high.

The California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (USEPA) currently recognize the following air pollutants as “criteria air pollutants” based on their prevalence and harmful impact on human health: ozone, particulate matter (PM), nitrogen dioxide (NO_2), CO, sulfur dioxide (SO_2), and lead. Both National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS) have been developed for criteria air pollutants and regional attainment status of each contaminant is shown in **Table E-1**. Each of the criteria pollutant is identified as attainment, nonattainment, or unclassified by the State and USEPA, based on their number of violations and whether they meet national primary or secondary standards[5].

[5] In the State of California, a county is evaluated based on frequency of violations, instances in which the concentration of a pollutant is higher than the State standard which have not determined to be caused by an exceptional event. An area is designated as Nonattainment if the area has one or more violations (see definition below) within the last three years. Attainment is the category given to an area with no violations in the last three years. Finally, Unclassified is the category given to an area with insufficient data (CARB 2014a). In National designations, an area is designated as Nonattainment if it does not meet (or contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant. An area is designated as Attainment if it meets the national primary or secondary ambient air quality standard for the pollutant. An area is designated as Unclassifiable if it cannot be classified on the basis of available information as meeting or not meeting the national primary or secondary ambient air quality standard for the pollutant (EPA 2014).

Table E-1: State and Federal Ambient Air Quality Standards and Attainment Status

Pollutant	Averaging Time	(State) SAAQS[1]		(Federal) NAAQS[2]	
		Standard	County Attainment Status	Standard	County Attainment Status
Ozone (ROG)	One hour	0.09 ppm	N	NA	NA
	Eight hour	0.07 ppm	N	0.075 ppm	N/Marginal
Carbon Monoxide (CO)	One hour	20 ppm	A	35 ppm	U/A
Nitrogen Dioxide (NO_2)	One hour	0.18 ppm	A	0.100 ppm	U/A
Sulfur Dioxide (SO_2)	One hour	0.25 ppm	A	0.075 ppm	A
Particulate Matter (PM_{10})	24 hour	50 µg/m^3	N	150 µg/m^3	U
Fine Particulate Matter ($PM_{2.5}$)	Annual	12 µg/m^3	N	15 µg/m^3	N
Lead	30 day/Quarterly	1.5 µg/m^3	A	0.15 µg/m^3	U/A
Sulfates	24 Hour	25 µg/m^3	A	NA	ND
Hydrogen Sulfide	One Hour	0.03 ppm	U	NA	ND
Visibility-Reducing Particles	Eight Hour	Extinction of 0.23 per kilometer	U	NA	ND

Source: CARB 2014a and 2014b.

Footnotes: A = Attainment; N = Nonattainment; U = Unclassified; NA = Not Applicable, no applicable standard; ND = no designation; ppm = parts per million; µg/m3 = micrograms per cubic meter.

1. SAAQS = state ambient air quality standards (California). SAAQS for ozone, carbon monoxide, sulfur dioxide (one-hour and 24-hour), nitrogen dioxide, particulate matter, and visibility-reducing particles are values that are not to be exceeded. All other state standards shown are values not to be equaled or exceeded. (CARB 2013).
2. NAAQS = national ambient air quality standards. NAAQS, other than ozone and particulates, and those based on annual averages, are not to be exceeded more than once a year. The eight-hour ozone standard is attained when the three-year average of the fourth highest daily concentration is 0.08 ppm or less. On June 15, 2005 the 1 hour ozone standard was revoked for all areas except the 8-hour ozone nonattainment Early Action Compact Areas (EAC) areas (those do not yet have an effective date for their 8-hour designations). The 24-hour PM_{10} standard is attained when the three-year average of the 99th percentile of monitored concentrations is less than the standard. The 24-hour $PM_{2.5}$ standard is attained when the three-year average of the 98th percentile is less than the standard. CO areas have been redesignated to maintenance areas. (CARB 2013).

On June 2, 2010, BAAQMD's Board of Directors unanimously adopted thresholds of significance to assist in the review of projects under CEQA. These thresholds were designed to establish the level at which the District believed air pollution emissions would cause significant environmental impacts under CEQA and were posted on the Air District's website and included in the Air District's updated CEQA Guidelines (BAAQMD, updated 2012). A lawsuit ensued wherein the Alameda County Superior Court issued a judgment in 2012 finding that the BAAQMD had failed to comply with CEQA when it adopted the thresholds of significance in the BAAQMD CEQA Air Quality Guidelines; however, it did not address the merits of the science or evidence supporting the thresholds. The judgment by the County was reversed by the District Court of Appeal, who upheld the BAAQMD's CEQA Guidelines in 2013. The California

Supreme Court has granted review on the issue of whether toxic contaminants thresholds are consistent with CEQA. For the purposes of this analysis, the City is using the updated CEQA guidelines shown in **Table E-2** as the basis of the criteria pollutant thresholds.

Table E-2: Bay Area Air Quality Management District Air Quality Mass Daily Significance Thresholds

Pollutant	Construction (lbs/day)	Operation (lbs/day)	Operation (tons/year)
Nitrogen Oxides (NO_x)	54	54	10
Volatile Organic Compounds (VOC)	54	54	10
Particulate Matter (PM_{10})	82	82	15
Fine Particulate Matter ($PM_{2.5}$)	54	54	10
Sulfur Oxides (SO_x)	None	None	
Carbon Monoxide (CO)	None	9.0 ppm (8 hour), 20.0 ppm (1 hour)	
Lead	None	None	

Source: BAAQMD. 2009 and 2010.

Some population groups, such as children, the elderly, and acutely ill and chronically ill persons, especially those with cardio-respiratory diseases, are considered more sensitive to air pollution than others. Schools are considered sensitive receptors for air quality issues because children are more susceptible than adults to the effects of many criteria pollutants. Sensitive receptor locations include schools, parks and playgrounds, day care centers, nursing homes, hospitals, and residential dwelling units. Sensitive receptor locations in the Study Area include: El Carmelo Elementary School, Fairmeadow Elementary School, Jane L. Stanford Middle School, Gunn High School, Sunshine Preschool, Sora International Preschool of Palo Alto, Keys School, Grace Lutheran Preschool (all located within one-quarter mile of the proposed pipeline alignment) and Fairmeadow Elementary School (located adjacent to one of the proposed laterals) and Jane L. Stanford Middle School (located in proximity to the same proposed lateral). In addition, other facilities used by children, including Ramos Park, Mitchell Park Community Center and Library, Wilbur Playground, Hoover Park, and the soccer fields located on a site previously occupied by Mayfield School, are located along the proposed pipeline alignment, with other parks and a library located within one-quarter mile (Sarah Wallis Park, Weisshaar Park, College Terrace Library, Mayfield Park, and Kite Hill).

EMISSIONS ESTIMATES

Impacts on air quality were determined by modeling the quantity of contaminants produced during project construction and operation. The project was split into pump station construction and pipeline construction, the latter of which was further analyzed based on two types of construction practices. Pipeline construction according to open trench and horizontal directional drilling approaches were both modeled using the Road Construction Emissions Model, Version 7.1.5.1. The two pump stations required as part of the pipeline system were modeled in CalEEMod, Version 2013.2.2. Assumptions used in the model, including but not limited to the physical length of the proposed pipeline alignment, the dimensions of the proposed trenches and pits, the number of work crews, and the rate of construction, are consistent with the assumptions used in the calculation of soil import and export volumes presented in *Chapter 2, Project Description.* These assumptions are conservative in that they assume that 100 percent of the material excavated would be exported and subsequently imported although likely much of the material would be reused for backfilling.

The model also assumes that all applicable basic and additional construction emission control measures identified in the BAAQMD CEQA Guidelines are implemented. **Table E-3** and **Table E-4** summarize the air quality emissions from construction and operation of the proposed Project. The raw model results are provided in **Appendix I** of this EIR.

Calculated estimates were compared to BAAQMD's mass daily thresholds for construction and operational activities for VOC, NO_x, CO, PM_{10}, and $PM_{2.5}$. The maximum construction emissions would take place during grading and excavation periods associated with soil import and export trips and off-road equipment use. The maximum construction emission levels are therefore calculated by evaluating the construction of each element separately. Potential emissions during operation would result from vehicle trips for daily inspection and maintenance; as the pump stations would be operated using electricity, air pollutant emissions from pumping are not anticipated.

Table E-3: Criteria Pollutant Emissions Generated from Pipeline Construction

Construction Method	Maximum Daily Construction Emissions (lbs/day)					
	VOC	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$
Open Trench	8.70	85.0	53.0	--	7.20	4.10
Horizontal Directional Drilling (HDD)	4.80	34.8	31.4	--	1.20	1.30
Construction Emission Thresholds[1]	54	54	None	None	82	54
Significant Construction Emissions						
Open Trench	NO	YES	NO	NO	NO	NO
HDD	NO	NO	NO	NO	NO	NO

1. Thresholds based on BAAQMD Proposed Air Quality CEQA Thresholds of Significance (BAAQMD 2010).
2. Both techniques assume two crews would be working simultaneously.

Source: RMC using Roadway Construction Emissions Model (Version 7.1.5.1, 2013) included in Appendix I.

Table E-4: Criteria Pollutant Emissions from Pump Station Construction

Project Components	Maximum Daily Construction Emissions (lbs/day)					
	VOC	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$
Pump Station at Mayfield Soccer Field	3.57	41.1	42.9	0.120	4.48	2.09
Pump Station at the RWQCP[1]	1.68	17.5	18.0	0.0425	2.23	1.26
Total Pump Station Construction Emissions	5.25	58.6	60.9	0.16	6.71	3.35
Project Total Operation Emissions[2]	-	-	-	-	-	-
Construction Emission Thresholds[3]	54	54	None	None	82	54
Operation Emission Thresholds[3]	54	54	See Table E-2	None	82	54
Significant Construction Emissions	NO	YES	NO	NO	NO	NO

1. RWQCP = Regional Water Quality Control Plant
2. As described below, operations and maintenance for the Project would be incorporated into the current operations and maintenance activities in the area and would thus have no increase in emissions.
3. Thresholds based on BAAQMD Proposed Air Quality CEQA Thresholds of Significance (BAAQMD 2010).

Source: RMC using CalEEMod model (2013.2.2, 2013) and custom energy consumption calculations included in Appendix I.

Potential air quality emissions were also evaluated with respect to Federal General Conformity Rule Thresholds. The Federal General Conformity Rule requires analysis based on conformance with an applicable State Implementation Plan, National Environmental Policy Act (NEPA), and the Federal Clean Air Act (CAA). **Table E-5** provides an overview of emissions associated with the Proposed Project/Action as they relate to compliance with the Federal General Conformity Rule. As shown in **Table E-5**, emissions would not exceed Federal General Conformity significance thresholds.

Table E-5: Project Compliance with Federal General Conformity Rule

Project Components	Annual Construction Emission (Tons/Year)					
	VOC	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$
Pipeline Construction[1a]						
Open Trench	1.00	8.90	5.90	-	0.80	0.50
Horizontal Directional Drilling	0.60	3.90	4.20	-	0.20	0.20
Pump Stations[1b]						
Mayfield Soccer Field	0.10	1.14	1.00	0.00258	0.11	0.06
RWQCP	0.07	0.76	0.65	0.00130	0.07	0.05
Maximum Construction Emissions	1.00	8.90	5.90	-	0.80	0.50
Maximum Operation Emissions[2]	-	-	-	-	-	-
Federal General Conformity Rule Thresholds[3]	10	100	100	100	100	100
10% of BAAQMD Emissions Inventory[4]	26.50	31.76	127.20	2.30	11.89	4.56
Significant Construction Emissions	NO	NO	NO	NO	NO	NO

1. Calculations for construction were completed using: a) Roadway Construction Emissions Model (Version 7.1.5.1, 2013) and b) CalEEMod model (2013.2.2, 2013) and are included in Attachment I.
2. As described below, operations and maintenance for the Project would be incorporated into the current operations and maintenance activities in the area and would thus have no recognizable increase in emissions.
3. Thresholds applied by Federal General Conformity Rule [40 CFR 93.153(b)(1)].
4. Emissions are estimated for 2012 in Tons/day and used evaluate emissions with respect to the Federal General Conformity Rule (CARB 2013).

Sources: EPA 2014a and 2014b.

DISCUSSION

The proposed Project includes excavation activities and construction that would generate fugitive dust and other criteria pollutants. Construction contract provisions would include a dust abatement program as outlined in the Project Description (standard project requirement that is also presented below). Daily combustion emission impacts from construction vehicles would not be significant due to the relatively small scale of the Project. Criteria pollutant emissions from these emission sources would incrementally add to regional atmospheric loading of ozone precursors during the construction period. Emissions calculations for construction and operation of the proposed Project are included in Appendix I.

a) **Less-than-Significant Impact.** The proposed Project is located within the jurisdiction of the BAAQMD, which regulates air quality through its permit authority over most types of stationary emission sources and through its planning and review process. To meet planning requirements related to the Nonattainment status of the SFBAAB, the BAAQMD has developed a regional air quality plan, the Bay Area 2010 Clean Air Plan (CAP)[6] (BAAQMD, 2010). A significant impact would occur if a project conflicted with the plan by not mirroring assumptions of the plan to attain air quality standards; reduce population exposure and protecting public health in the Bay Area; and reduce greenhouse gas emissions and protect the climate.

The proposed Project would accommodate population growth because the Project would provide recycled water, making potable supplies more available, and thus increasing the overall supply of water. However, because growth in the City of Palo Alto is controlled by the Palo Alto Comprehensive Plan, the new water supply as a result of the proposed Project is not expected to result in increased development. The proposed Project would not generate new operational vehicle trips. Pump station maintenance would be completed as part of the regular maintenance trips that are already occurring in the Project area. The Project would not conflict with or obstruct implementation of the 2010 CAP, and this impact would be less than significant. No mitigation is required.

With respect to project conformity with the federal CAA, the Project's potential emissions are below minimum thresholds (see **Table E-5** above) and are well below 10 percent of the area's inventory specified for each criteria pollutant designated non-attainment or maintenance for the Bay Area. As such, further general conformity analysis is not required.

b) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** Overall construction work would require the use of various types of mostly diesel-powered equipment, including bulldozers, wheel loaders, excavators, and various kinds of trucks. Construction activities typically result in emissions of particulate matter, usually in the form of fugitive dust from activities such as trenching and grading. Emissions of particulate matter vary day to day, depending on the level and type of activity, silt content of the soil, and the prevailing weather. In the absence of a dust control plan, construction activities may result in significant quantities of dust on a temporary and intermittent basis during the construction period.

As shown in **Table E-3** and **Table E-4** above, construction of the proposed pipeline (using the open trench technique) or construction of the pump station(s) (either simultaneously or at the same time with pipeline construction) by two crews simultaneously would result in exceeded of the BAAQMD NO_x threshold. Thus, exceedance of BAAQMD thresholds would be considered a significant impact requiring implementation **Mitigation Measure AIR-1** (either limiting the number of crews working at any one time if open trench construction is taken or refining the construction scenario such that more accurate information can be used to rerun the model to determine if No_x emissions would exceed BAAQMD thresholds). A model run of the one-crew scenario using the same assumptions as the two-crew scenario confirms that it would reduce No_x emissions below BAAQMD thresholds. Implementation of this measure would reduce potential impacts to less than significant.

Constructing the proposed pipeline using HDD pipeline construction under the two-crew scenario would not result in exceedance of any of the BAAQMD thresholds. Thus,

[6] The purpose of the 2010 Bay Area CAP is to provides a comprehensive plan to improve Bay Area air quality and protect public health. Specifically, the CAP defines a control strategy to: (1) reduce emissions and decrease ambient concentrations of harmful pollutants; (2) safeguard public health by reducing exposure to air pollutants that pose the greatest health risk, with an emphasis on protecting the communities most heavily impacted by air pollution; and (3) reduce greenhouse gas (GHG) emissions to protect the climate.

implementation of this construction technique would result in less-than-significant air quality impacts, and no mitigation is required.

Emissions sources resulting from Project operations would be associated with regular maintenance and inspection work and energy use. As stated above, operations and maintenance of the proposed facilities would be incorporated into the existing maintenance regime and thus would not result in increased emissions. Indirect emissions related to energy use would result in greenhouse gas emissions (GHG) which are addressed in the GHG section (see Section E.6, Greenhouse Gas Emissions). Operation of the proposed Project would therefore result in a less-than-significant air quality impact and no mitigation is required.

c) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** As stated above, the proposed Project would be located within the Bay Area Air Basin, which does not meet state and federal health-based air quality standards for the state PM_{10} and $PM_{2.5}$ standards, the state 1-hour, and the national 8-hour ozone standards.

As shown in **Tables E-3** and **E-4**, emissions of PM_{10} and $PM_{2.5}$ from construction of the proposed Project would be below the thresholds applicable to the SFBAAB. However, if a combination of the proposed pipeline alignments (using open trench construction) and pump stations were constructed concurrently by two crews, then NO_x thresholds would exceed BAAQMD thresholds as discussed in item a) above, which would contribute to regional increases in ozone and particulate matter. Thus, impacts are considered potentially significant and would require mitigation. Implementation of the standard project requirement (BAAQMD dust control measures) and **Mitigation Measure AIR-1** would ensure that the proposed Project would not result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment and impacts would be reduced to less than significant.

d) **Less than Significant Impact.** The Project would not be expected to emit hazardous air pollutants other than diesel particulate matter during construction from diesel-powered construction vehicles and any diesel trucks associated with Project operation. The California Office of Environmental Health Hazard Assessment (OEHHA) currently describes the health risk from diesel exhaust entirely in terms of the amount of particulate matter ($PM_{2.5}$) emitted. Currently, the health risk associated with diesel exhaust $PM_{2.5}$ is characterized as a carcinogenic and chronic effect[7]; thus, no short-term acute effect is currently recognized.

Cancer risk assessment as currently practiced involves estimating exposure to carcinogenic chemicals and multiplying the dose times the cancer potency factor (BAAQMD, 2012). Results of the SCREEN3 air quality model shows that cancer risks associated with each component of the project would be less than 1 in one million (well below the threshold of 10 in one million).

In accordance with OEHHA's risk assessment guidelines, chronic non-cancer hazards should be assessed for inhalation and non-inhalation (e.g., ingestion and dermal contact) chronic exposures (BAAQMD, 2012). The proposed Project would consist only of short-term construction activities (approximately one year) and no long-term operational diesel-particulate producing activities,

[7] Chronic effect is characterized as a long-term effect.

Based on the discussion above, the proposed Project would not expose sensitive receptors to substantial levels of toxic air contaminants and impacts would be less than significant.

As noted above, with the implementation of the standard project requirement and **Mitigation Measure AIR-1**, the Project would further reduce $PM_{2.5}$ during construction.

With respect to operations, the proposed pump stations would be operated by electricity and thus would not emit localized emissions. As such, operation of the Project would not expose sensitive receptors to substantial levels of toxic air contaminants.

e) **Less-than-Significant Impact.** During construction of the proposed Project, the various diesel-powered vehicles and equipment in use on site could create minor odors. These odors are not likely to be noticeable beyond the immediate area, and would be temporary in nature. Furthermore, the proposed Project would not include development of any uses of recycled water that are associated with objectionable odors. Given the extent to which the recycled water is treated, odors are not expected to be a problem at or near water use sites, at or near the pump station (which would underground or at the RWQCP), or in the event of a pipeline rupture. Therefore, odor impacts would be less than significant. No mitigation is required.

f) **No Impact.** As all applicable construction emission control measures recommended in the BAAQMD CEQA Guidelines would be implemented for the proposed Project, no impact would occur.

STANDARD PROJECT REQUIREMENT

BAAQMD Dust Control Measures

The following basic construction measures are identified by BAAQMD and shall be incorporated into contract specifications and implemented by the contractor.

- All exposed surfaces (e.g., parking areas, staging areas, soil piles, graded areas, and unpaved access roads) shall be watered two times per day;
- All haul trucks transporting soils, sand, or other loose material off-site shall be covered;
- All visible mud or dirt track-out onto adjacent public roads shall be removed using wet power vacuum street sweepers at least once per day. The use of dry power sweeping is prohibited;
- All vehicle speeds on unpaved roads shall be limited to 15 mph;
- All roadways, driveways, and sidewalks to be paved shall be completed as soon as possible. Building pads shall be laid as soon as possible after grading unless seeding or soil binders are used;
- Idling times shall be minimized either by shutting equipment off when not in use or reducing the maximum idling time to 5 minutes (as required by the California airborne toxics control measure Title 13, Section 2485 of California Code of Regulations). Clear signage shall be provided for construction workers at all access points;
- All construction equipment shall be maintained and properly tuned in accordance with manufacturer’s specifications. All equipment shall be checked by a certified visible emissions evaluator; and
- Post a publicly visible sign with telephone number and person to contact at the lead agency regarding dust complaints. This person shall respond and take corrective action within 48 hours. The Air District’s phone number shall also be visible to ensure compliance with applicable regulations.

The following additional construction mitigation measures identified by BAAQMD shall be incorporated into contract specifications and implemented by the contractor, to supplement the proposed standard project requirement.

- All exposed surfaces shall be watered at a frequency adequate to maintain minimum soil moisture of 12 percent. Moisture content can be verified by lab samples or moisture probe.
- All excavation, grading, and/or demolition activities shall be suspended when average wind speeds exceed 20 mph.
- Wind breaks (e.g., trees, fences) shall be installed on the windward side(s) of actively disturbed areas of construction. Wind breaks should have at maximum 50 percent air porosity.
- Vegetative ground cover (e.g., fast-germinating native grass seed) shall be planted in disturbed areas as soon as possible and watered appropriately until vegetation is established.
- The simultaneous occurrence of excavation, grading, and ground-disturbing construction activities on the same area at any one time shall be limited. Activities shall be phased to reduce the amount of disturbed surfaces at any one time.
- All trucks and equipment, including their tires, shall be washed off prior to leaving the site.
- Site accesses to a distance of 100 feet from the paved road shall be treated with a 6 to 12 inch compacted layer of wood chips, mulch or gravel.
- Sandbags or other erosion control measures shall be installed to prevent silt runoff to public roadways from sites with a slope greater than one percent.
- Idling time of diesel powered construction equipment shall be minimized to two minutes.
- The project shall develop a plan demonstrating that off-road equipment (more than 50 horsepower) to be used in the construction project (i.e., owned, leased, and subcontractor vehicles) would achieve a project wide fleet-average 20 percent NO_x reduction and 45 percent PM reduction compared to the most recent ARB fleet average. Acceptable options for reducing emissions include the use of late model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, add-on devices such as particulate filters, and/or other options as such become available.
- Use low VOC (i.e., ROG) coatings beyond the local requirements (i.e., Regulation 8, Rule 3: Architectural Coatings).
- All construction equipment, diesel trucks and generators shall be equipped with Best Available Control Technology for emission reductions of NO_x and PM.
- All contractors shall use equipment that meets CARB's most recent certification standard for off-road heavy duty diesel engines.

MITIGATION MEASURES

Mitigation Measure AIR-1. Two Crew Construction of Proposed Pipeline (using open trench construction technique) and Pump Station Restrictions.

To ensure NO_x emissions do not exceed the BAAQMD threshold, the City shall either:

1. Incorporate into contract specifications the requirement for contractors to limit open trench construction of the proposed pipeline to one crew (rather than two crews) and sequence the pump station construction so that it would be constructed one at a time, not concurrent with any other activity; or

2. Upon refinement of the construction details and assumptions for equipment use, dimensions of the trenches, rate of construction, backfill volume, the City shall rerun the air quality model analysis to confirm whether simultaneous construction of the proposed pipeline or pump stations would result in exceedance of BAAAMD NO_x emissions thresholds. If NO_x thresholds is exceeded, then the City shall implemented item 1 above. If NO_x thresholds is not exceeded, then the City would be able to proceed with concurrent construction of two pipelines (using open trench construction) / two pump stations accordingly.

E.3. BIOLOGICAL RESOURCES

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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, including 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?			✓		
c) 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?				✓	
d) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or as defined by the City of Palo Alto's Tree Preservation Ordinance (Municipal Code Section 8.10)?			✓		
e) Conflict with any applicable Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?				✓	

SETTING

The information provided below is based on the findings of the Biological Resources Assessment (BRA) conducted for the proposed Project (MIG, 2015). This report is included as **Appendix J** of this EIR.

The majority of the proposed Project area consists of developed land. Additional vegetation communities—disturbed habitat, ornamental vegetation, creek, and pastureland—occur within the proposed Project area.

Sensitive plant communities identified by the California Department of Fish and Wildlife (CDFW) near the proposed project include Northern Coastal Salt Marsh, Valley Oak Woodland, and Serpentine Bunchgrass. However, no sensitive natural community types are present in or in the vicinity of the proposed project alignment.

A literature search was conducted to identify the background information pertaining to the biological resources in the vicinity of the proposed Project. The special status plant and wildlife species that have been documented in the vicinity of the project are included in the BRA in **Appendix J**. Two surveys were conducted along the proposed alignment and stream crossings and pump stations. The first survey, to assess the existing conditions in the Project area, was conducted on May 20, 2011. The second survey, conducted on November 5, 2014, was to confirm the biological conditions along the proposed project alignment and at the RWQCP had not changed appreciably since 2011.

Special-Status Plants

Based upon a review of species occurrence databases, it was determined that 47 special-status plant species have been documented in the vicinity of the Project area. Based on a review of available databases and literature, and an assessment of the types of habitats within the Project area, it was determined that none of the special-status plant species are expected to occur within the Project area (i.e., all special-status plant species were ranked as “Not Expected” or “Low Potential”).

Special-Status Animals

Based upon a review of species occurrence databases, it was determined that 34 special-status animal species are known to or have the potential to occur in the vicinity of the Project area. Of these animal species, 30 are not expected to occur within the Project area, Based on biological surveys and habitat suitability analysis conducted by biologists in May 2011 and November 2014, a total of four special-status animal species (California red-legged frog [CRLF], burrowing owl [BUOW], Northern Harrier [NOHA], and Salt Marsh Common Yellowthroat [SMCY]) are assumed to have a moderate potential to occur in the project vicinity. Other migratory birds and raptors and bats could also occur in the Project area. They are described below.

<u>Amphibians</u>

<u>California red-legged frog</u>

California red-legged frog (*Rana draytonii*) is listed as federally threatened and is designated by the state as a California Species of Special Concern (CSSC). CRLF occurs in different habitats depending on life stage, season, and weather conditions. CRLF typically use a variety of aquatic habitats (e.g., ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, perennial creeks, artificial ponds, marshes, dune ponds, and lagoons), as well as riparian and upland habitats. The common factor among habitats where CRLF occur is the association with a permanent water source, ideally free of non-native predators. Although CRLF is largely absent from urban and suburban settings, potential habitat is present within close proximity to the Project area within Matadero Creek near Hillview Avenue. Potential habitat is also present northwest of the Project area within Matadero Creek near Deer Creek Road. Several occurrences of CRLF have been recorded in the California Natural Diversity Database (CNDDB) within 5 miles of the Project area. Three adults and five larvae were observed in an artificial pond 0.5 mile south southwest of Bear Gulch Reservoir in 1998. Multiple adults, tadpoles, and juveniles were observed in Matadero Creek, Deer Creek, and San Francisquito Creek between 1997 and 2001. One juvenile was observed in an unnamed creek 0.4 mile southeast of Bear Gulch Reservoir in 2003. Based on the presence of moderately suitable habitat and on recent and nearby CNDDB occurrences, CRLF are considered to have a moderate potential to occur within the proposed Project area.

Birds

Burrowing Owl

Burrowing owl (*Athene cunicularia*) is designated as a CSSC by the CDFW. The BUOW is a ground dwelling owl, typically found nesting in arid prairies, fields, and open areas where vegetation is sparse and low to the ground. It is heavily dependent upon the presence of mammal burrows (e.g., ground squirrel) in its habitat to provide shelter from predators or inclement weather, as well as to provide a nesting location. Foraging habitat is often present in grassland areas. The BUOW has disappeared from a significant portion of its range in the last 15 years. Nearly 60 percent of the breeding groups of BUOW known to have existed in California during the 1980s had disappeared by the early 1990s. The conversion of grassland habitat has been a significant factor in the reduction of the local population. Because burrowing owls depend on other animals to dig their burrows, eradication of ground squirrels has also contributed to their decreased numbers. At present, approximately 50 pairs of BUOW remain in the entire county of Santa Clara. There are multiple occurrences of BUOW nesting and overwintering within 5 miles of the proposed Project area, including three occurrences of overwintering owls at nearby Byxbee Park as recently as March 2014. There has been no breeding documented at Byxbee Park since the early 1900s, but BUOW are known to breed within 2.5 miles at Shoreline Park in Mountain View. Pastureland habitat in the southern portion of the Project area between Hillview Avenue and Deer Creek Road provides marginally suitable foraging and breeding habitat. Suitable foraging and breeding habitat is also present within the disturbed marsh habitat near the RWQCP and additional foraging habitat is present at Byxbee Park near the RWQCP. Based on the presence of moderately suitable habitat and on recent and nearby CNDDB occurrences, BUOW are considered to have a moderate potential to occur within the proposed Project area.

California Clapper Rail

California clapper rail (*Rallus longirostris obsoletus*) is federally- and state-listed as endangered. The clapper rail is a year-round resident of the San Francisco Bay associated with salt and brackish marshes traversed by tidal sloughs. In the South and Central San Francisco Bay, clapper rails typically inhabit salt marshes dominated by pickleweed (*Salicornia pacifica*) and cordgrass (*Spartina foliosa*). Nesting begins in late March, peaking in late-April and May, and extends into early July.

Potential foraging and nesting habitat for clapper rails does not occur in much of the Project area. However, the RWQCP is located within the Baylands Preserve, which contains northern coastal salt marsh habitat, which is potential habitat for clapper rails. There are several occurrences of clapper rail recorded in the CNDDB within a five-mile radius of the Project. The potential for construction-related activities to adversely affect clapper rails is considered low given the existing levels of human-related disturbances in the Project vicinity, but the USFWS and CDFW typically recommend surveys be conducted for projects within 500 feet of potential nesting habitat to avoid disturbance of clapper rails during the nesting season.

Northern Harrier

Northern harrier (*Circus cyaneus*) is designated as a CSSC by the CDFW. It nests and forages in fresh and saltwater marshes, and is seen fairly often foraging in upland grasslands. This medium-sized raptor often flies close to the ground while hunting for small mammals and birds. The male and female of this species differ greatly in appearance. The female is larger than the male and has dominantly brown colored plumage while the male has predominantly gray plumage. Both the male and female have white rumps that are obvious during flight. There are three CNDDB occurrences of nesting NOHA within 5 miles of the proposed Project area. All three of these occurrences are in salt marsh habitat. The Project area does not support any suitable nesting habitat, but NOHA have a moderate potential to forage within the pastureland habitat at the southern portion of the proposed Project area. Marshland areas north and east of the Project area support suitable nesting and foraging habitat for NOHA; therefore, they could be expected to fly through the Project area. NOHA is considered to have a moderate potential to occur within the proposed Project area.

Salt Mash Common Yellowthroat

Salt marsh common yellowthroat (*Geothlypis trichas sinuosa*) is designated as a CSSC by the CDFW. This species inhabits thick, tangled vegetation, particularly in wet areas. In Santa Clara County, SMCY is a regular breeder and is fairly common in the fall, winter, and spring, and common in the summer. Nesting sites for SMCY may be over water, in emergent aquatic vegetation, dense shrubs, or other dense growth. Nests are typically on or within 10 centimeters of the ground. The nesting season generally extends from early April to mid-July, with peak activity in May and June.

The Project area does not support potential nesting habitat for SMCY. However, this species may occasionally forage within the Project area, particularly east of East Bayshore Road in the vicinity of the preferred alignment and at the crossings of Adobe Creek at Highway 101 and East Meadow Drive. Potential nesting habitat is present in the marsh and riparian habitats within the Baylands Marsh Nature Preserve. There are several occurrences of SMCY recorded in the CNDDB within 5 miles of the proposed Project area, including a record from 1985 of five breeding pairs at the end of Mayfield Slough, a record at the junction with Matadero Creek, and a record from 1985 of two breeding pairs at Adobe Creek just east of Hwy 101. Therefore, SMCY may fly through the Project area to reach suitable foraging and nesting habitat. As a result, SMCY is considered to have a moderate potential to occur within the proposed Project area.

Other Migratory Birds and Raptors

In addition to the bird species discussed above, habitats in the vicinity of the project, particularly the northern coastal salt marsh, coastal freshwater marsh, and willow riparian habitats east of the Project area, support potential nesting habitat for other migratory birds and raptors, such as American kestrel (*Falco sparverius*), red-winged blackbird (*Agelaius phoeniceus*), western meadowlark (*Sturnella neglecta*), and yellow warbler (*Dendroica petechia brewsteri*). In addition, the ornamental vegetation interspersed throughout the urban area, such as landscape trees, support potential nesting habitat for common migratory species, such as house finch (*Carpodacus mexicanus*), Anna's hummingbird (*Calypte anna*), Mourning dove (*Zenaida macroura*), and bushtit (*Psaltriparus minimus*). The roadway overpasses and recreational bridges crossing the creeks within the Project area also support potential nesting habitat for those species that attach their nests to structures, such as cliff swallow (*Petrochelidon pyrrhonata*), barn swallow (*Hirundo rustica*), and black phoebe (*Sayornis nigricans*). Although only some of these species are listed by the CDFW and/or USFWS, all are protected under the Migratory Bird Treaty Act (MBTA), which prohibits taking, killing, possessing, transporting, and importing of migratory birds, and their eggs and nests, except when specifically authorized by the Department of Interior. The term "take" is defined as meaning, "to pursue, hunt, capture, collect, kill or attempt to pursue, hunt, shoot, capture, collect or kill, unless the context otherwise requires." Disturbances that cause nest abandonment and/or loss of reproductive effort or loss of habitat upon which these birds depend would be in violation of the MBTA, as well as other state and federal regulations for those species specifically protected by the federal or California Endangered Species Act.

Bat species

The creek crossings, oak woodlands, and grassland habitats adjacent to the Project area could provide foraging and marginal roosting habitat for the pallid bat (*Antrozous pallidus*, CSSC) and Townsend's big-eared bat (*Corynorhinus townsendii*, CSSC). CNDDB occurrences for the pallid bat and Townsend's big-eared bat have been documented within 5 miles of the Project area (CDFW 2014). Additionally, the Project area does provide some suitable foraging habitat in the trees and bridges at the Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near

Cowper Street. Bridges frequently have structural features very similar to natural roosts, and the large mass, particularly in concrete bridges, offers the kind of thermal buffering that bats require. They frequently serve to replace natural roosts in anthropogenically-altered landscapes (Erickson et al. 2003). Additionally, bats tend to forage near water sources, and so roadway bridges over water bodies are even more likely to serve as roosting sites. Therefore, these species, as well as several other non-sensitive bat species, have potential to use roadway bridges and landscape trees as day or night roosting locations.

DISCUSSION

a) Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.

Special-status Plants

No special-status plant species or suitable habitat for special-status plant species were observed within the Project area during the biological surveys in May 2011 and November 2014. In addition, no sensitive plant species with a moderate or high potential to occur within the Project area were identified during the literature review. Some special-status plant species were identified during the literature review as having a low potential to occur in the proposed Project area. However, because proposed construction activities would occur within previously disturbed areas (e.g., paved roads or along existing maintained right of way), special-status plant species with a low potential to occur are not anticipated to be impacted. As such, no impacts to special-status plants from the proposed Project are anticipated.

Special-status Animals

This discussion focuses on construction-related effects because operation of the proposed Project would not have any potential impact on wildlife species. CRLF has potential to occur within Matadero Creek and in the pastureland habitat between Deer Creek Road and Hillview Avenue. Construction of the proposed Project could result in temporary indirect impacts to CRLF, such as displacing CRLF due to increased noise levels or decreased habitat quality due to temporarily decreasing water quality. There is also some potential for direct impacts to CRLF in these areas if a CRLF is present in the proposed Project area. However, with implementation of the standard project requirements proposed as part of this Project (e.g., developing and implementing a Stormwater Pollution Prevention Plan [SWPPP], implementing best management practices [BMPs]), **Mitigation Measure BIO-1** (general measure to avoid impacts to sensitive habitats), **Mitigation Measure BIO-2** (conducting activities in the dry season when feasible to address potential effects to CRLF), **Mitigation Measure BIO-3** (conducting environmental awareness training), **Mitigation Measure BIO-4** (retaining a qualified biologist to monitor construction in these areas), and **Mitigation Measure BIO-5** (general measures to reduce impacts to wildlife species), impacts would be reduced to less than significant.

NOHA and SMCY have the potential to forage in the proposed Project area and to nest adjacent to the proposed Project area. Impacts to nesting NOHA and SMCY are not anticipated as a result of the proposed project because no suitable habitat is present within the Project area. However, foraging NOHA and SMCY could be temporarily impacted during construction activities due to increased noise levels and human activity in the work areas. Since there is an abundance of additional foraging habitat present in the immediate vicinity of the proposed Project area, impacts to foraging NOHA and SMCY are anticipated to be less-than-significant.

Breeding, wintering, or foraging BUOW could occur near the RWQCP and within the pastureland habitat at the southern section of the Project area between Deer Creek Road and Hillview Avenue.

Impacts to burrowing owl may include the removal of potential breeding or wintering habitat (e.g., destruction of ground squirrel burrows) and the disruption of breeding, wintering, or foraging behavior due to a temporary increase in noise from construction equipment and vehicles. However, the majority of the proposed project is located in an industrial area near major roadways (including Embarcadero Road, Highway 101, and Page Mill Road) and near existing facilities (including the SAP campus, RWQCP, and the landfill); therefore, impacts from construction noise are not anticipated to increase substantially from existing levels. In addition, with implementation of standard project requirements proposed as part of this Project, **Mitigation Measure BIO-6** (pre-construction surveys)**,** and **Mitigation Measure BIO-5,** impacts would be reduced to less than significant.

Although California Clapper Rail (CCR) (*Rallus longirostris obsoletus*) was determined to have low potential to occur in the proposed Project area because it is more than 500 feet away from any known, documented nesting sites, impacts to CCR could occur because of the presence of suitable habitat along Embarcadero Way. However, this habitat is more than 470 feet from the proposed construction activities and it is unlikely that impacts to CCR would occur due to Project implementation. Impacts to CCR include the disruption of breeding or foraging behavior due to a temporary increase in noise from construction equipment and vehicles. Because of the reclusive nature of this species disturbance could be difficult to detect; therefore, it is assumed that impacts to CCR could occur if construction activities take place within 500 feet of suitable marshland habitat for CCR. However, given that an existing road (i.e., Embarcadero Road), which is used by landfill vehicles, is present between the marshland habitat where CCR may occur and the RWQCP where construction activities would occur, noise and disruption from construction are not anticipated to increase substantially from existing levels along Embarcadero Road. **Mitigation Measure BIO-7** (e.g., avoiding the breeding season to the extent feasible or conducting protocol-level CCR surveys prior to construction within 500 feet of marshland habitat to determine presence or absence) would reduce potential impacts to CCR to less than significant.

The use of recycled water would not affect any special-status wildlife species. The City currently provides recycled water under its waste discharge requirements for the City of Palo Alto RWQCP (Order No. 93-160) to provide recycled water to new customers proposed as part of this project. Prohibitions of the permit include the following:

- No reclaimed [recycled] water used for irrigation shall be applied during periods of rainfall or when soils are saturated such that runoff occurs;
- No reclaimed [recycled] water used for irrigation shall be allowed to escape to areas outside the designated use areas by surface flow or by airborne spray.
- No reclaimed [recycled] water shall be discharged from the treatment facilities, irrigation holding tanks, storage ponds, man-made marsh, or other containment, other than for irrigation or industrial reuse in accordance with this Order or for discharge to a municipal sewage collection system.

The prohibitions above would ensure that there is no recycled water runoff from irrigation sites into any sensitive habitat that could affect the habitat or special-status animal species. Thus, no impacts would occur.

Nesting Birds

Some common avian species may nest within or in the vicinity of the proposed Project area. Impacts to nesting bird species may include the removal of potential nesting habitat (e.g., ornamental vegetation, trees) and the disruption of nesting behavior due to a temporary increase in noise from construction equipment and vehicles. However, the majority of the proposed project alignment is located in highly developed areas near major roadways (including Embarcadero Road, Highway 101, and Page Mill Road). Therefore, impacts from construction noise are not anticipated to increase substantially from existing levels. **Mitigation Measures BIO-5** and **BIO-8** (conducting pre-construction nesting bird surveys during the breeding season) would reduce impacts to nesting birds to less-than-significant.

Bats

Bat species may forage or roost within the proposed Project area, especially in the vicinity of the Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street. Noise, vibration, and increased light can lead to the temporary disturbance of roosting or foraging bats. In addition, if bats are roosting under the bridges at these crossings, they could be temporarily displaced from roosting at these locations during activities associated with the installation of the pipeline on or in the vicinity of the bridge. **Mitigation Measures BIO-9** and **BIO-10** (protection of bats) would reduce impacts to roosting bat species to less-than-significant.

Implementation of the above mitigation measures would reduce potential adverse effects to special-status animal species to a less than significant level.

b) Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated. Sensitive vegetation communities include riparian habitat or other sensitive natural communities identified in local or regional plans, policies, or regulations, or as designated by the USFWS and CDFW. No sensitive natural communities are present within the proposed Project area. However, because sensitive natural communities are present in the vicinity of the Project area, the proposed Project could have indirect impacts (e.g., inadvertent damage by construction equipment or decreased water/habitat quality due to runoff) on these sensitive natural communities. The standard project requirements proposed as part of the proposed Project and **Mitigation Measure BIO-1** would ensure that impacts would be reduced to less-than-significant.

Three jurisdictional waters (i.e., Adobe Creek, Barron Creek, and Matadero Creek) are present within the proposed Project area. No direct impacts to these waters would occur because all pipelines would be constructed either by hanging from a bridge or using trenchless construction beneath the channel. Trenchless construction would be accomplished without surface disturbance of the channels; however, construction must be performed carefully to avoid the risk (albeit highly unlikely) of an uncontrolled release of drilling fluids into the stream from construction of the pipeline (i.e., frac-out). Implementation of the Frac-Out Plan standard project requirement (see **Chapter 2**) would protect against frac-out. The proposed project could have indirect impacts (e.g., inadvertent damage by construction equipment or decreased water/habitat quality due to runoff) on these jurisdictional waters. However, with the implementation of standard project requirements proposed as part of the proposed Project and **Mitigation Measure BIO-1**, impacts would be reduced to less than significant.

c) Less-than-Significant Impact. Although wildlife may use the Project area as a travel route as they move between the habitats in the project vicinity and those adjacent to the Project area or as a stepping stone during larger scale movements, the project is primarily urban and is not located within an established movement corridor. Additionally, the project is not a known wildlife nursery site. All proposed creek crossings would use trenchless techniques that would not impact resident or migratory fish. For these reasons, construction and operation of the proposed project would not impact wildlife corridors or nursery sites.

d) Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated. The Palo Alto Comprehensive Plan (Palo Alto 2007) and the Palo Alto Municipal Code protect biological resources within the City's limits. Compliance with the **Mitigation Measures BIO-1** through **BIO-10** would reduce potential impacts to less than significant.

The City's Comprehensive plan defines policies for protecting creeks and riparian areas, wetlands, urban forest, and wildlife. Implementation of measures prescribed in items a), b) above would ensure conformance with local regulations. Regulated trees (protected trees, street trees growing within the street right-of-way, and designated trees) could be removed during the construction activities and as such could conflict with the City's Municipal Code and the Tree Technical Manual. Any necessary tree removal would occur on City owned land, public utility easement, or on leased or private property (e.g., Mayfield Soccer Fields, parking lot adjacent to Fabian Road). Protected trees would remain. Designated trees would be protected or replaced according to the Tree Canopy Replacement Formula, Tree Technical Manual, Section 3.30, and street trees would be replaced with species determined by Public Works Operations. Tree removal of non-protected trees could occur on City owned land, PUE, private property (e.g., Mayfield Soccer Fields), or leased land. The City must comply with the Tree Technical Manual regarding the removal and replacement of trees (see standard project requirement). Compliance with the Manual's practices would ensure that potential conflicts would be reduced to less than significant.

The installation of the proposed alignment, alignment options, and laterals at creek crossings could require work within Santa Clara Valley Water District's (SCVWD's) jurisdiction. Such activities would conflict with the SCVWD's Water Resources Protection Ordinance (Ordinance 06-1). Prior to the onset of construction activities, an encroachment permit application shall be submitted to the SCVWD. Modification or use of facilities and/or easements within SCVWD jurisdiction shall not occur until the permit is received, or correspondence is received indicating that a permit is not required.

Installation of the pump station at the RWQCP would not conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance. The pump station would comply with the requirements of both the Baylands Master Plan and Santa Clara County's Airport Master Plan for the Palo Alto Airport. The trees on the site proposed for the pump station at the RWQCP are not protected by City of Palo Alto Municipal Code Chapter 8.10.

e) Less than Significant Impact. The proposed project is within the area covered by the Stanford University HCP. The proposed project is not covered by the HCP. The mitigation measures described above are compatible with the HCP. As a result, the proposed project would not conflict with the HCP. No Natural Community Conservation Plans, or other local or regional plans have been adopted within the City, which encompasses the study area.

STANDARD PROJECT REQUIREMENTS

Health and Safety and Hazardous Materials Management and Spill Prevention Control Plans

The City shall require the contractor to prepare a Health and Safety Plan and Hazardous Materials Management and Spill Prevention and Control Plan prior to commencement of construction that includes a project-specific contingency plan for hazardous materials and waste operations. The Health and Safety Plan shall be applicable to all construction activities, and shall establish policies and procedures according to federal and California Occupational Safety and Health Administration (OSHA) regulations for hazardous materials Health and Safety Plans, and the City of Palo Alto's Pollution Prevention plan sheet.

Elements of the plan shall include, but not be limited to, the following:

- Discussion of hazardous materials management, including delineation of hazardous material storage areas, access and egress routes, waterways, emergency assembly areas, and temporary hazardous waste storage areas;
- Notification and documentation of procedures; and
- Spill control and countermeasures, including employee spill prevention/response training.

Best Management Practices – Stormwater Quality

The City shall require contractors to file a Notice of Intent with the Regional Water Quality Control Board (RWQCB) indicating compliance with the National Pollutant Discharge Elimination System (NPDES) General Permit for Discharges of Storm Water Runoff Associated with Construction Activity (General Permit) and to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) outlining BMPs for construction/post-construction activities as specified by the City of Palo Alto's Pollution Prevention plan sheet, the California Stormwater Best Management Practices Handbook and/or the Association of Bay Area Governments' Manual of Standards for Erosion and Sediment Control Measures. The BMPs include measures guiding the management and operation of construction sites to control and minimize the potential contribution of pollutants to stormwater runoff from these areas. These measures address procedures for controlling erosion and sedimentation, and managing all aspects of the construction process to ensure control of potential water pollution sources. Erosion and sedimentation control practices typically include:

- Installation of silt fencing and/or straw wattle;
- Soil stabilization;
- Revegetation of graded and fill areas with a standard erosion control mix (approved by a native habitat restorationist);
- Runoff control to limit increases in sediment in stormwater runoff (e.g., straw bales, silt fences, drainage swales, geofabrics, check dams, and sand bag dikes);
- Performing equipment maintenance at least 100 feet from all water bodies and wetlands, with measures in place to contain spills of diesel fuel, gasoline, or other petroleum products.
- Directing drainage from all work sites away from any water bodies or wetlands where feasible;
- Preventing erosion of uplands and sedimentation of creeks, tributaries, and ponds;
- Minimizing creek bank instability;
- Preventing flooding; and
- Returning grades to preconstruction contours.

A SWPPP that complies with the statewide General Permit shall be developed and implemented to protect water quality of the creeks that lie in the study area. Appropriate erosion and sediment control and non-sediment pollution control (i.e., sources of pollution generated by construction equipment and material) BMPs shall be prescribed in the SWPPP, and erosion and sediment control material included in the SWPPP shall be certified as weed free. Dewatering operations are covered under the General Construction Permit as an authorized non-stormwater discharge. The discharge from dewatering operations would be evaluated and made part of the Project SWPPP. In addition, the Project shall comply with RWQCB regulations and standards to maintain and improve the quality of both surface water and groundwater resources.

Compliance with the Tree Technical Manual

The City of Palo Alto *Tree Technical Manual* (Dockter 2001) is a separately published document issued by the City Manager, through the Departments of Planning and Community Environment and Public Works to establish specific technical regulations, standards and specifications necessary to implement the Tree Ordinance (Chapter 8.10, Tree Preservation and Management Regulations), and to achieve the City's tree preservation goals and natural resource conservation goals.

Section 2.00 specifically addresses the protection of trees during construction; its objective is to reduce the negative impacts of construction on trees[8] to a less than significant level.

Construction projects within the tree protection zone (TPZ) of Regulated Trees[9] are required to implement protective practices prior to and during construction. The City would be required to retain a certified arborist to prepare a Tree Protection and Preservation Plan if any activity is within the dripline of a Protected or Designated Tree. The Plan must include an assessment of impacts to trees, recommended mitigation to reduce impacts to a less than significant level, and identification of construction guidelines to be followed through all phases of a construction project.

Section 3.00 of the Tree Technical Manual outlines requirements associated with the removal and replacement of regulated trees. The standards and specifications for replacements of trees are dependent on the location where a Protected or Designated Tree would be replaced. If a tree is to be replaced on site, the replacement tree must be the same species unless the Director determines that another species would be more suitable for the location. The location of the replacement tree on site must be approved by the Director. If it is not possible to replace the tree on site, funding for the replacement of trees is calculated using a Tree Value Replacement Standard. The funding is then applied for planting of trees elsewhere.

MITIGATION MEASURES

The following mitigation measures address the potential impacts of the Project to biological resources within or adjacent to the study area. Implementation of these measures would reduce potential impacts to a less-than-significant level.

Mitigation Measure BIO-1: Protection of Sensitive Habitats and Jurisdictional Features. The proposed project has been designed to avoid impacts to sensitive habitats, including jurisdictional wetlands and waters. However, indirect impacts to jurisdictional waters could occur as a result of the proposed

[8] Typical negative impacts identified in the City's Tree Technical Manual include the following: 1) mechanical injury to roots, trunk or branches; 2) compaction of soil, which degrades the functioning roots and inhibits the development of new ones and restricts drainage, which desiccates roots and enables water mold fungi to develop; 3) changes in existing grade which can cut or suffocate roots; 4) alteration of the water table - either raising or lowering; 5) microclimate change, exposing sheltered trees to sun or wind; and 6) sterile soil conditions, associated with stripping off topsoil.

[9] Regulated Trees identified in the Tree Technical Manual include the following:

- Protected Trees: All coast live oak (*Quercus agrifolia)*, valley oak (*Quercus lobata)* trees that are 11.5-inches or greater in diameter (36-inches in circumference measured at 54-inches above natural grade) and coast redwood (*Sequoia sempervirens)* trees that are 18-inches or greater in diameter (57-inches in circumference measured at 54-inches above natural grade) and Heritage Trees, individual trees of any size or species designated as such by City Council per the Palo Alto Municipal Code (PAMC) Section 8.10.
- Street Trees: All trees growing within the street right-of-way (publicly-owned), outside of private property. In some cases, property lines lie several feet behind the sidewalks. A permit from the Public Works Department is required prior to any work on or within the dripline of any 'street tree' per PAMC Section 8.04.
- Designated Trees: All trees, when associated with a development project, that are specifically designated by the City to be saved and protected on a public or private property which is subject to a discretionary development review per PAMC Section 18.76.

project. The following general measures will be implemented during the construction and operation of the proposed project to minimize indirect impacts to sensitive habitats and jurisdictional features:

- All construction equipment will use identified staging areas and access roads located in upland areas. When accessing work sites, travel and parking of vehicles and equipment will be limited to pavement, existing roads, and previously disturbed areas (except where overland travel is required). Construction workers will not be allowed to enter sensitive areas that have been fenced or staked.
- Ground disturbance and vegetation removal will not exceed the minimum amount necessary to complete work at the site.
- The following BMPs shall be incorporated into the SWPPP as protective measures to address wind- or water-related erosion:
  - No discharge of pollutants from vehicle and equipment cleaning will be allowed into storm drains, wetlands, or water courses.
  - No vehicles may be refueled within 100 feet of wetlands, streams, or other waterways. Vehicles operating adjacent to wetlands and waterways must be inspected and maintained daily to prevent leaks.
  - Waste facilities will be maintained. Waste facilities include concrete wash-out facilities, portable toilets, and hydraulic fluid containers. Waste will be removed to a proper disposal site.
- After construction is completed, a final cleanup will include removal of all stakes, temporary fencing, flagging, and other refuse generated by construction.

Mitigation Measure BIO-2: Protection of CRLF. Construction activities associated with the creek crossing (Matadero Creek near Deer Creek Road) will be limited to the dry season (generally April 15 to October 15) to the extent feasible.

Mitigation Measure BIO-3: Employee Education Program (required for CRLF, BUOW, and CCR if preconstruction surveys determine they are present). An employee education program will be conducted by a qualified biologist, consisting of a brief presentation to explain special-status species concerns to contractors, their employees, and any other personnel involved in the project. The program will include the following: a description of relevant special-status species and their habitat needs as they pertain to the project; a report of the occurrence of these species in the project vicinity, as applicable; an explanation of the status of these species and their protection under the MBTA, California Fish and Game Code, and other statutes; and, a list of measures being taken to reduce potential impacts to natural resources during project construction and implementation. A fact sheet conveying this information will be prepared for distribution to the above-mentioned people and anyone else who may enter the project area. Upon completion of training, employees will sign a form stating that they attended the training and understand all of the conservation and protection measures. Construction crews will be informed during the education program meeting that, to the extent possible, travel within the marked project area will be restricted to established roadbeds.

Mitigation Measure BIO-4: Monitoring During Construction. A qualified biologist will be retained to monitor construction activities associated with the creek crossing (Matadero Creek near Deer Creek Road). The biologist will have expertise with CRLF biology and ecology. The biologist will have the authority to halt work if a special-status species is observed.

Mitigation Measure BIO-5: General Measures to Reduce Impacts to Wildlife Species. The following shall be relevant to the following species: California red-legged frog, burrowing owl, and the California Clapper Rail.

- All excavations left open overnight will either be covered to prevent wildlife from becoming entrapped or will include escape ramps. In addition, excavations must be inspected for wildlife at the start of each workday and prior to back filling. The USFWS and/or CDFW will be contacted prior to removing or relocating any special-status wildlife within the excavation.
- Food items may attract wildlife into construction areas, which would expose them to construction-related hazards. The construction areas will be maintained in a clean condition. All trash (e.g., food scraps, cans, bottles, containers, wrappers, cigarette butts, and other discarded items) will be placed in closed containers and properly disposed of.
- If an animal is found at a work site and is believed to be a protected species, work must be halted until the animal leaves of its own accord or the USFWS and/or CDFW is consulted to relocate the species. Care shall be taken not to harm the species. No wildlife or plant species will be handled and/or removed from the site by anyone except approved biologists.

Mitigation Measure BIO-6: Burrowing Owl Pre-Construction Surveys. Pre-construction BUOW surveys will be conducted in suitable habitat for BUOW (i.e., in pastureland habitat between Deer Creek Road and Hillview Avenue and in the vicinity of the RWQCP) in accordance with the recommendations and guidelines provided in the Staff Report on Burrowing Owl Mitigation (Department of Fish and Game, March 2012). If no BUOW or BUOW sign is observed no further action will be required. If BUOW or BUOW sign is observed then no disturbance will occur within 160 feet of occupied burrows during the non-breeding season (September 1 through January 31) or within 250 feet during the breeding season (February 1 through August 31). A qualified biologist will be present in these locations to monitor construction and ensure the BUOW is not disturbed.

Mitigation Measure BIO-7: Buffer for California Clapper Rail or Survey. Construction activities within 500 feet of the marshland habitat surrounding the RWQCP will be conducted outside the breeding season for CCR (i.e., September 1 through January 31). If this is not feasible, a qualified biologist will conduct protocol-level surveys for CCR in accordance with the California Clapper Rail Draft Survey Protocol (USFWS 2000). A qualified biologist is an individual who has experience conducting protocol-level surveys for CCR. Prior to commencement of the surveys, the biologist will prepare a brief letter report describing the survey design and submit it to the USFWS and the CDFW for review and approval. Upon the completion of the surveys, results will be submitted to the USFWS and CDFW for a final decision on the possibility of doing work during the breeding season for CCR.

Mitigation Measure BIO-8: Measure to Protect Nesting Birds. If equipment staging, site preparation, grading, excavation, or other project-related construction activities are scheduled to occur during the avian nesting season (generally February 1 to September 1), a focused survey for active nests will be conducted by a qualified biologists within 15 days prior to the beginning of project-related activities. Surveys will be conducted in all suitable habitat located at project work sites, and in staging or storage areas. Surveys will be conducted at the appropriate times of day (e.g., dawn or dusk), and during the appropriate nesting times and will concentrate on areas of suitable habitat. If a lapse in project-related activities of 15 days or longer occurs, another focused survey will be conducted. If no active nests are found, then no further mitigation is required. If an active nest is found within the surveyed areas, an appropriate exclusion buffer will be established by a qualified biologist and the exclusion buffer will be maintained until the young have fledged or will no longer be impacted by the project. A qualified biologist will be present to monitor construction activities in the vicinity of the nest and ensure the nesting species is not disturbed. If a species appears disturbed by construction activities (as determined by a qualified biologist) work will be halted and the

USFWS and/or CDFW will be consulted. Project activities will not resume without approval from the USFWS and/or CDFW.

Mitigation Measure BIO-9: Bat Preconstruction Surveys. Preconstruction day and night-roost surveys will be conducted to avoid impacts to bats. The survey will be conducted by a qualified bat biologist following the protocol in the Bats and Bridges Technical Bulletin (Erickson et al. 2003) to determine if bats are using the bridges as a roost site. If a roost is observed, the CDFW and/or USFWS will be consulted and additional mitigation measures will be implemented. Example measures include working during the daytime if night roosts are present, no clearing or grubbing adjacent to the roost, no work within 100 feet of the roost, no lighting near the roost where it could shine on the roost structure.

Mitigation Measure BIO-10: Bat Breeding Season Surveys. Construction activities near the Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street will be scheduled to avoid the bat breeding season (April through August) to the extent feasible. If work in these locations is required in the breeding season, a survey for bats will be conducted. The survey will be conducted by a qualified bat biologist following the protocol in the Bats and Bridges Technical Bulletin (Erickson et al. 2003) to determine if bats are using the bridges as a roost site. If a roost is observed, the CDFW and/or USFWS will be consulted and additional mitigation measures will be implemented. Example measures include excluding bats from directly affected work areas or replacing the roost location.

E.4 CULTURAL RESOURCES

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Directly or indirectly destroy a local cultural resource that is recognized by City Council resolution?			✓		
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to 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?			✓		
e) Adversely affect a historic resource listed or eligible for listing on the National and/or California Register, or listed on the City's Historic Inventory?			✓		
f) Eliminate important examples of major periods of California history or prehistory?			✓		

SETTING

The information provided below is based on the findings of the Cultural Resources Assessment Report conducted for the proposed Project (WSA, 2015). This report is included as **Appendix K** of this EIR.

Records Search

Records searches of pertinent survey and site data were conducted at the Northwest Information Center (NWIC) at Sonoma State University by William Self Associates (WSA). The initial record searches (File No. 07-0362, 07-1299) covered the entire Project area and a one-quarter mile radius adjacent thereto. A later record search (File No. 07-1326) was conducted at the request of Cookie Hirn of the Division of Financial Assistance, at the State Water Resources Control Board (SWRCB), upon an initial review of the report for the purpose of examining the archaeological potential of closely associated areas located between the proposed routes of the pipeline backbone and laterals. The most recent search of the proposed Project area was conducted on October 23, 2014 (File No. 14-0533). Previous surveys, studies and archaeological site records were accessed as they pertained to the Project area. The record search included a review of the California Inventory of Historic Resources (1976), the Historic Property Directory (Office of Historic Preservation current computer list), NWIC records of archaeological sites and surveys, GLO Plats, historic maps, and other pertinent historic data available at the NWIC for Santa Clara County. A total of 91 cultural resource studies have been conducted within 1/4 mile of the Project Area of Potential Effect (APE). Twenty-two (22) studies include or cross some portion of the Project components. The remaining 69 studies do not include Project components but have been conducted within ¼-mile of the Project APE.

The results of the search indicated that one previously recorded resource (a historic railroad) crosses the Project APE and 15 other previously recorded archaeological sites are located within ¼-mile of the Project area. The historic resource is a segment of the Southern Pacific Railroad that is now Caltrain[10]. The prehistoric sites include 12 prehistoric shell middens and 3 prehistoric quarry areas.

Survey Methods

A field reconnaissance of the proposed Palo Alto Recycled Water Project was conducted on September 17, 2007 by WSA Staff Archaeologist, Melinda Hickman, M.A. Due to the extensive development in the APE, a windshield survey was conducted. As the APE is centered almost entirely on roadways paved in concrete, a windshield survey was considered suitable for this reconnaissance. This method of surveying involves traveling through the APE in order to search for standing historic structures and undeveloped parcels of land that may exhibit evidence of buried cultural resources. A follow up pedestrian archaeological survey of the proposed Project area was conducted on October 24, 2014.

All areas identified as being potentially sensitive for cultural materials were examined for the presence of historic or prehistoric site indicators. Historic site indicators include, but are not limited to foundations, fence lines, ditches, standing buildings, objects or structures such as sheds, or concentrations of materials at least 50 years in age, such as domestic refuse (glass bottles, ceramics, toys, buttons or leather shoes), or refuse from other pursuits such as agriculture (e.g., metal tanks, farm machinery parts, horse shoes) or structural materials (e.g., nails, glass window panes, corrugated metal, wood posts or planks, metal pipes and fittings). Prehistoric site indicators include, but are not limited to areas of darker soil with concentrations of ash, charcoal, bits of animal bone (burned or unburned), shell, flaked stone, ground stone, or human bone.

No historic or prehistoric cultural resources were observed within the APE and no new archaeological sites were identified during the survey.

Archaeological Sensitivity of the Project Area - Vertical APE

A formal vertical Area of Potential Effects (APE) map was prepared to analyze the relationship between construction disturbance and archaeological sensitivity in accordance with the direction of SWRCB and United States Bureau of Reclamation (USBR). The map was based on an archaeological sensitivity model that took into account the soil type, slope, and distance to nearest water to calculate areas of high, medium and low archaeological potential within the Project area. The archaeological sensitivity study is based on a soils report prepared for the Project by David DeVries of Mesa Technical in Berkeley, California[11].

The results of the archaeological sensitivity modeling of the Project area identified seven areas of either high or high to moderate archaeological sensitivity.

- The Adobe Creek crossing on East Meadow Drive is located in an area of high archaeological sensitivity

[10] The tracks associated with the segment of the railroad alignment crossed by the project have been replaced and upgraded at least twice since the original railroad was constructed and the line no longer retains its integrity of setting, feeling, and association.
[11] The purpose of the study was to evaluate archaeological sensitivity for buried cultural features, within soils and sediments to be disturbed by Project-related construction activity.

- The Adobe Creek crossing along Middlefield Road is located in an area of high archaeological sensitivity
- The Barron Creek crossing along Cowper Street is located in an area of high archaeological sensitivity
- The Matadero Creek crossing along Cowper Street is located in an area of high archaeological sensitivity
- The lateral line along Arastradero Road northeast from the intersection with Miranda Avenue is located in an area of high archaeological sensitivity
- The Matadero Creek crossing along Hillview Avenue is located in an area of high to moderate archaeological sensitivity
- The Barron Creek crossing along Miranda Avenue is located in an area of high to moderate archaeological sensitivity

Due to urbanization and channelization of creeks, ground visibility in these areas was minimal during the archaeological pedestrian survey. Consequently, the field reconnaissance was unable to assess the potential that historic properties are present in these areas.

Native American Consultation

When the individuals on the list of interested Native Americans provided by the NAHC were contacted in 2007 regarding this Project, no responses to letters were received. Follow up phone calls elicited a few general responses recommending Native American monitors during construction of the pipeline. Due to minor changes in the original project, WSA reinitiated Native American consultation. WSA contacted the NAHC by email on October 22, 2014, requesting information on sacred lands and traditional cultural properties that might be present within the Project area, and a list of local tribal representatives. A response was received from the NAHC on November 5, 2014 indicating that a record search in the sacred land file did not indicate the presence of Native American cultural resources in the immediate Project area but provided a list of Santa Clara County Native American contacts. WSA contacted the Native American representatives by certified letter, on November 18, 2014, informing them of the Project and requesting any information they might have regarding sacred sites or traditional cultural properties within the Project area.

DISCUSSION

a-b, d-f) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The records searches conducted in support of the Cultural Resources Report indicated that no National or State listed historical or prehistorical sites occur within the project APE. Fifteen previously recorded archaeological sites and one previously recorded historic site are located within ¼-mile of the Project area. Only the historic railroad site would cross a proposed alignment. However, because this segment of the historic property is not recommended as eligible for listing in the National Register of Historic Places (NRHP) or the California Register of Historical Resources (CRHR), and Project construction would avoid the railroad tracks through trenchless construction techniques, no physical changes to the railroad segment would occur. In addition, the Project would not cause a substantial adverse change to any previously recorded historical or archaeological resources, but because portions of the project are located within areas of archaeological sensitivity based on the records searches and the archaeological sensitivity modeling conducted for the Project, there is a potential for encountering previously unrecorded cultural resources. Thus, the standard project requirement proposed as part of the Project and **Mitigation Measure CR-1** would be needed to reduce potential effects.

Although the records search, windshield survey, and consultation with Native Americas failed to indicate the presence of human remains within the vicinity of the project, the subsurface excavation required for construction of the project could potentially disturb or destroy previously undiscovered archaeological resources or human remains from both prehistoric and historic time periods, if they are present. However, this impact would be minimized through the implementation of the standard project requirements proposed as part of the Project and **Mitigation Measure CR-1** below. As a result, the impact would be reduced to less than significant.

c) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** According to the Existing Conditions Report, there have been paleontological remains discovered in the Palo Alto area in the past, most of which are small marine fossils such as claims and snails. Paleontological remains have been identified around Stanford University, the Stanford Medical Center, and San Francisquito Creek. Due to the presence of paleontological sites in the vicinity, the potential for impacts to the paleontological resources is considered significant. However with the implementation of standard project requirement (protection of paleontological resources), such effects would be reduced to less than significant.

STANDARD PROJECT REQUIREMENTS

Protection of Cultural Resources

Should any previously undiscovered historic or prehistoric archaeological deposits be discovered during construction, work shall stop within 50 feet of the discovery, until such time that the discovery can be evaluated by a qualified archaeologist and appropriate mitigative action taken as determined necessary in consultation with the lead Federal agency for NHPA Section 106 compliance, in accordance with 36 CFR Part 800.13, and the City. Measures might include preserving in situ the archaeological resource or an archaeological monitoring or data recovery program. Prehistoric archaeological site indicators include chipped chert and obsidian tools, and tool manufacturing waste flakes, grinding implements such as mortars and pestles, and darkened soil that contains dietary debris such as bone fragments and shellfish remains. Historic site indicators include, but are not limited to, ceramics, glass, wood, bone, and metal remains.

Section 7050.5(b) of the California Health and Safety code will be implemented in the event that human remains, or possible human remains, are located during Project-related construction excavation. Section 7050.5(b) states:

> In the event of discovery or recognition of any human remains in any location other than a dedicated cemetery, there shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent remains until the coroner of the county in which the human remains are discovered has determined, in accordance with Chapter 10 (commencing with Section 27460) of Part 3 of Division 2 of Title 3 of the Government Code, that the remains are not subject to the provisions of Section 27492 of the Government Code or any other related provisions of law concerning investigation of the circumstances, manner and cause of death, and the recommendations concerning treatment and disposition of the human remains have been made to the person responsible for the excavation, or to his or her authorized representative, in the manner provided in Section 5097.98 of the Public Resources Code.

The County Coroner, upon recognizing the remains as being of Native American origin, is responsible for contacting the Native American Heritage Commission (NAHC) within 24 hours. The Commission has various powers and duties to provide for the ultimate disposition of any Native American remains, as does the assigned Most Likely Descendant. Sections 5097.98 and 5097.99 of the Public Resources Code also call for protection from inadvertent destruction. To achieve this goal, the construction personnel on the

Project would be instructed as to the potential for discovery of cultural or human remains, the need for proper and timely reporting of such finds, and the consequences of failure thereof.

Protection of Paleontological Resources

If paleontological resources are discovered during earthmoving activities, the construction crew would immediately cease work near the find. In accordance with Society of Vertebrate Paleontology guidelines (Society of Vertebrate Paleontology 2010), a qualified paleontologist would assess the nature and importance of the find and recommend appropriate salvage, treatment, and future monitoring and mitigation.

MITIGATION MEASURES

Mitigation Measure CR-1: Subsurface Testing

A program of sub-surface testing shall be conducted to determine whether buried resources are present within the areas of high or high to moderate archaeological sensitivity that will be impacted by Project construction. Only those locations where design confirms that the proposed pipeline would be buried at archaeologically sensitive locations will require subsurface testing. A testing program will be developed to determine the best approach for each location, considering the physical constraints of the urban setting (e.g., structures, traffic). The testing program could consist of multiple core extractions at individual sites; the locations and depths of the bore holes would be determined on the basis of projected depths of excavation at the individual work areas. A qualified archaeologist would monitor the testing efforts, and inspect the cores for prehistoric archaeological site indicators (e.g., chipped chert and obsidian tools, and tool manufacturing waste flakes, grinding implements such as mortars and pestles, and darkened soil that contains dietary debris such as bone fragments and shellfish remains) and historic site indicators (e.g., ceramics, glass, wood, bone, and metal remains).

If the findings of the subsurface testing are negative, then no further actions (e.g., further testing or archaeological monitoring) would be recommended as necessary for NHPA Section 106 compliance, although consultation with SHPO would still be needed to formally complete the Section 106 process.

If the findings of the subsurface testing are positive (and avoidance of the archaeological site is not feasible or practicable through project redesign), then a qualified archaeologist will develop an archeological data recovery plan (ADRP) in consultation with the City, the lead Federal agency, the State Historic Preservation officer (SHPO) and other appropriate consulting parties, as applicable, in accordance with to the requirements of 36 CFR Part 800. The ADRP shall identify how the proposed data recovery program will used to evaluate and preserve the significant information the archaeological resource is expected to contain. That is, the ADRP will identify what scientific/historical research questions are applicable to the expected resource, what data classes the resource is expected to possess, and how the expected data classes would address the applicable research questions. Implementation of the ADRP through the development and execution of an appropriate agreement document by the lead Federal agency, the SHPO, the City, and any other identified signatories, would satisfy the requirements of NHPA Section 106 as outlined at 36 CFR § 800.6. Whether the results of subsurface testing are negative or positive, if Federal funding for the Project is approved, full compliance with Section 106 of the NHPA as determined by the lead Federal agency will be required prior to Project construction.

E.5 GEOLOGY, SOILS AND SEISMICITY

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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) Result in substantial siltation?			✓		
d) 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?			✓		
e) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?			✓		
f) 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?					✓
g) Expose people or property to major geologic hazards that cannot be mitigated through the use of standard engineering design and seismic safety techniques?					✓

SETTING

The geology of the site consists of the following: San Francisco Bay mud (Qhbm) adjacent to the shoreline, Alluvial fan deposits, fine facies (Qhff) next to the Bay mud, artificial fill over estuarine mud (afem) in the majority of the Project area, and alluvial fan deposits (Qhf) (R.C. Witter, K.L. Knudsen, J.M. Sowers, C.M. Wentworth, R.D. Koehler, and C.E. Randolph, 2006).

The Project area consists of the soils based on the Natural Resources Conservation Service as shown in **Table 3-2**, and shown in **Figure 3-1** in Section 3.3, Hydrology and Water Quality, in *Chapter 3, Environmental Setting, Impacts and Mitigation Measures*.

The Project area does not contain any Alquist-Priolo Fault Zones (ABAG, 2014a). The nearest quaternary[12] faults are the San Jose fault, the Palo Alto fault, and the Stanford fault that trends northwest, southeast in the Project area (CDC, 2010). Seismic-related hazards generated from earthquake fault activity include groundshaking, landslides, and liquefaction. The Association of Bay Area Governments (ABAG) maintains an interactive map of earthquake hazards for the San Francisco Bay Area. Proposed facilities would be located within a seismically active region of Northern California and are subject to moderate to very strong groundshaking (depending on the shaking scenario – i.e., the magnitude and fault). Shaking would be considered very strong to violent under the Northern San Andreas fault scenario at a magnitude of 7.9, with the violent designation encompassing the RWQCP. Due to the flatness of the Project area, earthquake induced landslides are not anticipated (ABAG, 2014b). USGS identified the liquefaction probability in Santa Clara County that would be caused by a magnitude 7.8 earthquake on the San Andreas Fault. The liquefaction probability would range from 0 to 10 percent (Holzer, T.L, et. al., 2008). The liquefaction susceptibility for the Project area ranges from Moderate to Very High (with the latter area occurring within the RWQCP area and along a segment of East Bayshore Road near the Project area (Witter, R.C. et. al, 2006; ABAG, 2014c).

DISCUSSION

a) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The proposed Project would not expose people to substantial adverse risks of loss, injury, or death from fault rupture, strong seismic groundshaking or related ground failure because the proposed Project does not include construction of habitable structures. Risk of pipeline rupture is low, and would not result in substantial adverse risk to people in the Project area. The site is not located within an Alquist-Priolo "Earthquake Fault Zone" for fault rupture hazard, and the potential for fault rupture to damage the pipeline is considered low.

The pipeline alignment is located in an area that would experience very strong to violent shaking in the event of a major earthquake along the San Andreas or Hayward Fault. With proper engineering (see the standard Project requirement below), the construction and operation of the proposed Project is not expected to result in any significant adverse short- or long-term impacts related to geology, soils, or seismicity.

The proposed pump station and associated connection pipeline at and near the RWQCP are located in an area classified as having very high liquefaction potential. The proposed pipeline alignments are located near reclaimed tidal baylands and an area classified as having a high liquefaction potential. The proposed pipeline alignments and pump station at the Mayfield Soccer Fields would not be within the reclaimed tidal baylands area. Adherence to generally accepted construction practices and implementation of standard Project requirements (prepare

[12] Quaternary faults are those active faults that have been recognized at the surface and which have evidence of movement in the past 1.6 million years or the duration of the Quaternary Period).

Geologic Report) would ensure that potential liquefaction impacts would be reduced to less than significant. Landslide potential is considered low due to the generally flat terrain of the Project area.

Because the pipeline is located within a previously graded, engineered, and developed area, potential for ground failure is considered to be low.

b,c) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** Construction activities involving soil disturbance, such as excavation, stockpiling, and grading would result in increased erosion, sedimentation and siltation to surface waters. Substantial erosion is considered unlikely because of the relatively small scale of earthmoving activities necessary for Project implementation. Implementation of standard engineering erosion-control techniques described in the Project Description and the implementation of the SWPPP, a standard project requirement proposed as part of the Project, would ensure that potential impacts to water quality are reduced to less than significant.

d) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The proposed project would be located on Bay mud, alluvial fan deposits, and artificial fill. Although no landslide, lateral spreading, subsidence, or collapse is expected, there is a potential for liquefaction in portions of the Project area (see discussion in item a) above). Implementation of the standard Project requirement below (prepare Geologic Report) would ensure that potential liquefaction impacts would be reduced to less than significant.

e) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The proposed pipeline alignment, laterals, and pipeline options, are not located in expansive soils as defined by the Uniform Building Code (UBC). The existing RWQCP facilities in the vicinity of the proposed RWQCP pump station site are supported on piles and the boring log for construction of the fixed film reactors at the RWQCP indicates bay mud. The presence of bay mud indicates the likely presence of expansive soils as defined by the UBC. If necessary, the proposed pump station would be constructed on piles to reduce the potential impacts of expansive soils. Implementation of the standard Project requirement below would ensure that potential impacts would be less than significant.

f) **No Impact.** No septic tanks are proposed for the Project. Therefore, no impacts are anticipated.

g) **No Impact.** The proposed project would not expose people or property to major geologic hazards that cannot be mitigated through the use of standard engineering design and seismic safety techniques. With proper engineering, the construction and operation of the proposed Project is not expected to result in any significant adverse short- or long-term impacts related to geology, soils, or seismicity.

STANDARD PROJECT REQUIREMENTS

Best Management Practices – Storm Water Quality

The City shall require contractors to file a Notice of Intent with the Regional Water Quality Control Board (RWQCB) indicating compliance with the National Pollutant Discharge Elimination System (NPDES) General Permit for Discharges of Storm Water Runoff Associated with Construction Activity (General Permit) and to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) outlining BMPs for construction/post-construction activities as specified by the City of Palo Alto's Pollution Prevention plan sheet, the California Stormwater Best Management Practices Handbook and/or the Association of Bay Area Governments' Manual of Standards for Erosion and Sediment Control Measures. The BMPs include measures guiding the management and operation of construction sites to control and minimize the potential contribution of pollutants to stormwater runoff from these areas. These measures address procedures for controlling erosion and sedimentation, and managing all aspects of the construction process to ensure control of potential water pollution sources. Erosion and sedimentation control practices typically include:

- Limiting construction to dry-weather months;
- Installation of silt fencing and/or straw wattle;
- Soil stabilization;
- Revegetation of graded and fill areas with a standard erosion control mix (approved by a native habitat restorationist);
- Runoff control to limit increases in sediment in stormwater runoff (e.g., straw bales, silt fences, drainage swales, geofabrics, check dams, and sand bag dikes);
- Equipment maintenance shall be performed at least 100 feet from all water bodies and wetlands, with measures in place to contain spills of diesel fuel, gasoline, or other petroleum products. Drainage from all work sites shall be directed away from any water bodies or wetlands where feasible;
- Prevent erosion of uplands and sedimentation of creeks, tributaries, and ponds;
- Minimize creek bank instability;
- Prevent flooding; and
- Return grades to preconstructed contours.

A SWPPP that complies with the statewide General Permit shall be developed and implemented to protect water quality of the creeks that lie in the study area. Appropriate erosion and sediment control and non-sediment pollution control (i.e., sources of pollution generated by construction equipment and material) BMPs shall be prescribed in the SWPPP, and erosion and sediment control material included in the SWPPP shall be certified as weed free. Dewatering operations are covered under the General Construction Permit as an authorized non-stormwater discharge. The discharge from dewatering operations would be evaluated and made part of the Project SWPPP. In addition, the Project shall comply with RWQCB regulations and standards to maintain and improve the quality of both surface water and groundwater resources.

Geologic Report for Potentially Affected Facilities

During the design phase for the Project, the City shall require preparation of a Geologic Report by a geologist registered in the State of California for facilities that could be affected by seismic-related hazards or unstable soils (e.g., liquefaction and expansive soils).

The Geologic Report shall include an engineering analysis of liquefaction and the potential for expansive soils at the pump stations. This assessment shall include a liquefaction assessment study in accordance with the California Geological Survey Special Publication 117 Guidelines. If this report finds unstable soils would present potential risks associated with liquefaction, engineering recommendations for surface and subsurface drainage specifications and detailed design for fill placement and excavation shall be provided.

MITIGATION MEASURE

No additional mitigation measures required.

E.6 GREENHOUSE GAS EMISSIONS

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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?				✓	

SETTING

Gases that trap heat in the atmosphere are referred to as greenhouse gases (GHGs) because they are transparent to solar radiation, but capture heat radiated by the earth back into the atmosphere, much like a greenhouse. The principal GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and water vapor (H_2O).

The accumulation of GHGs has been implicated as a driving force for global climate change. While the primary GHGs in the atmosphere are naturally occurring, the presence of CO_2, CH_4, and N_2O is largely the result of human activities that have accelerated the rate at which these compounds occur within the earth's atmosphere. CO_2 is the "reference gas" for climate change, meaning that emissions of GHGs are typically reported in "carbon dioxide-equivalents" (CO_2e).[13]

There is international scientific consensus that human-caused increases in GHGs have and will continue to contribute to climate change, although there is uncertainty concerning the magnitude and rate of the warming. The effects of climate change on the natural environment in California may include, but are not limited to extreme heat conditions that could last longer and become more frequent, reduced snowpack, and more frequent occurrence of high ozone days, large forest fires and drought years. Secondary effects are likely to include a global rise in sea level, impacts on agriculture, changes in geographic occurrence of disease vectors, and loss of habitats and biodiversity.

The CARB estimated that California produced 448.1 million metric tons (MMT) of CO_2e emissions in 2011. CARB found that transportation is the source of 38 percent of the state's GHG emissions, followed by industrial sources at 21 percent, electricity generation (both in-state and out-of-state) at 19 percent, and residential and commercial at 7 percent (CARB 2013).

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[13] Every GHG has a global warming potential (GWP), a measurement of the impact that the particular gas has on "radiative forcing" (i.e., the additional heat/energy that is retained in the earth's troposphere through the addition of this gas during a defined time period). CO_2 equivalents provide a universal standard of measurement against which the effects of releasing (or avoiding the release of) different GHGs can be evaluated. CH_4 has a GWP of 21 and N_2O has a GWP of 310, meaning that their effect on global warming would be 21 and 310 times greater, respectively, than an equivalent amount of CO_2.

BAAQMD is the agency principally responsible for comprehensive air pollution control in the San Francisco Bay Area Air Basin. Climate change and greenhouse gas (GHG) emissions have been addressed through a series of state legislation and executive orders, including the following:

- California Global Warming Solutions Act (AB 32) – Requires the state reduce emissions of GHG to 1990 levels by 2020.
- Executive Order S-3-05 – Set emission reduction targets: by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; and by 2050, reduce GHG emissions to 80 percent below 1990 levels.
- Executive Order S-01-07 – Mandates a statewide goal be established to reduce carbon intensity of California's transportation fuels by at least 10 percent by 2020.
- Title 24 – Established standards to allow consideration and possible incorporation of new energy efficiency technologies and methods.
- AB 1493 – Required CARB to develop and adopt regulations that reduce GHG emitted by passenger vehicles and light duty trucks.
- The Western Regional Climate Action Initiative – Signed by five states, including California, to collaborate to identify, evaluate, and implement ways to reduced GHG emissions in the states collectively and to achieve related co-benefits.

The BAAQMD approach to developing a Threshold of Significance for GHG emissions is to identify the emissions level for which a project would not be expected to substantially conflict with existing California legislation adopted to reduce statewide GHG emissions needed to move us towards climate stabilization. If a project would generate GHG emissions above the threshold level, it would be considered to contribute substantially to a cumulative impact, and would be considered significant.

The Thresholds of Significance for operational-related GHG emissions are:

- For land use development projects, the threshold is compliance with a qualified GHG reduction Strategy; or annual emissions less than 1,100 metric tons per year (MT/yr) of CO_2e; or 4.6 MT CO_2e/SP/yr (residents + employees). Land use development projects include residential, commercial, industrial, and public land uses and facilities.
- For stationary-source projects, the threshold is 10,000 MT/yr of CO_2e. Stationary-source projects include land uses that would accommodate processes and equipment that emit GHGs and would require an Air District permit to operate. If annual emissions of operational GHGs exceed these levels, the proposed project would result in a cumulatively considerable contribution of GHG emissions and a cumulatively significant impact to global climate change.

The BAAQMD does not recommend a construction emissions threshold for GHGs, however, the BAAQMD does encourage projects to quantify and disclose GHG emissions related to construction.

GHG emissions impact was determined by modeling the quantity of GHG emissions produced in project construction and operation. The project was split into individual components and further categorized by construction method. Pipeline construction was modeled linearly as the sum of total pipeline construction using the Road Construction Emissions Model, Version 7.1.5.1. Construction of each pump station was modeled in CalEEMod, Version 2013.2.2 using assumptions based on the Project Description.

GHG emissions from energy use by the pump stations were calculated by first converting the horsepower for each pump to kilowatt hour. The energy use was then multiplied by the greenhouse gas emission factor associated with City of Palo Alto Public Utilities obtained from the California Climate Action Registry, which equals 0.357 MT CO_2e/megawatt hours (MWh).

Table E-6 and **E-7** summarize the greenhouse gas emissions associated with the implementation of the proposed project.

Table E-6: Project Greenhouse Gas Emission from Pipeline Construction

Project Components	Construction Emission (MT CO_2e/Year)	Operation Emission (MT CO_2e/Year)
Open Trench with Two Crews	1,311	-
Horizontal Directional Drilling with Two Crews	883	-

Table E-7: Project Greenhouse Gas Emission from Pump Stations

Project Components	Construction Emission (MT CO_2e/Year)	Operation Emission (MT CO_2e/Year)
RWQCP	114	430
Soccer Field	225	491
Total GHG Emission	339	920

The modeled greenhouse gas emissions associated with construction of the pipeline total 1,311 MT CO_2e/year for open trench construction with two crews and 883 MT CO_2e/year for HDD construction with two crews. During project operation, there would be no new vehicle trips because pipeline and pump station maintenance would be completed as part of the regular maintenance trips that are already occurring in the Project area. The Project would therefore have no direct GHG emissions as a result of operations. GHGs emissions generated by construction of the pump stations are approximately 339 MT CO_2/year. The electric power used by the pumping stations would indirectly produce 920 MT CO_2e /year from the power generation plant.

DISCUSSION

a and b) Less-than Significant-Impact. The Project would generate GHGs during construction and ongoing operations. During construction, the use of heavy construction equipment during trenching and pipeline installation would be the primary source of GHGs. Construction of the proposed Project would generate more than 1,500 MT CO_2e/year. The GHG emissions would be substantially lower if HDD construction was used. Regardless of the scenario, these emissions would be temporary and would cease upon completion of construction. For that reason and given the relatively small-scale of construction, the Project is not expected to result in a net increase in GHG emissions that would significantly delay or hinder the State's ability to meet the reduction targets contained in California Governor's Executive Order S-3-05 and the impact is considered less than significant. The standard project requirement and **Mitigation Measure AIR-1** in *Section E.2, Air Quality*, would further reduce the Project's GHG emissions.

Following construction and with commencement of recycled water deliveries, the Project's operation is expected to generate GHG emissions well below the BAAQMD thresholds. Assuming pumping facilities would operate 24 hours a day, seven days a week annually; GHG emissions for the pump stations are estimated to be 920 MT CO_2e/year. This estimate is overly conservative as it assumes continual peak operation of the pumping facilities, which is not expected to occur under normal operating conditions. Despite the conservative nature of this analysis, estimated GHG emissions associated with the Project would not exceed the threshold of 1,100 MT CO_2e/yr for public facilities established by BAAQMD.

The operation of the pump stations would require the use of electricity. However, the electric load associated with the Project would take power from the City of Palo Alto electric utility (CPAU). Although electricity usage could increase as a result of project use, CPAU has made a significant commitment to purchase renewable "green" energy supplies and expects that the recycled water system would benefit from current efforts to increase supplies from resources with reduced GHG footprints. The Project could also subscribe to a CPAU commercial green pricing rate schedule so that there is no cumulative GHG increase contribution from the Project[14].

From a regional and statewide perspective, recycled water projects offer flexibility in reducing the need to pump potable water from distant locations for local deliveries. Considering the nexus between energy use and water delivery in California, recycled water projects could play an increasing role in future attempts to reduce both GHG emissions and energy consumption associated with any additional water deliveries.

Given the overwhelming scope of global climate change, it is not anticipated that a single development project would have an individually discernable effect on global climate change (e.g., that any increase in global temperature or rise in sea level could be attributed to the emissions resulting from one single development project). Rather, it is more appropriate to conclude that the GHG emissions generated by the proposed Project would combine with emissions across the state, nation, and globe to cumulatively contribute to global climate change.

In an effort to make a good faith effort at disclosing environmental impacts and to conform with the CEQA Guidelines [§16064(b)], it is the City's position that, based on the nature and size of this project, the proposed Project would not impede the state's ability to reach the emission reduction limits/standards set forth by the State of California by Executive Order S-3-05 and AB 32. For these reasons, this Project would not make a cumulatively considerable contribution to global climate change associated with GHG emissions. As such, impacts are considered less than significant.

MITIGATION MEASURE

No mitigation is required.

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[14] Palo Alto Green is a voluntary renewable energy program that allows customers to offset their energy use by paying a premium on their utility bill. The money is collected by the City to buy Renewable Energy Credits which in turn fund renewable energy projects statewide.

E.7 HAZARDS AND HAZARDOUS MATERIALS

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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) Construct a school on a property that is subject to hazards from hazardous materials contamination, emissions or accidental release?					✓
e) 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?			✓		
f) For a project located within an airport land use plan or, where such a plan has not been adopted, within two 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?				✓	
g) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working the project area?					✓
h) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?			✓		

i) 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?					✓
j) Create a significant hazard to the public or the environment from existing hazardous materials contamination by exposing future occupants or users of the site to contamination in excess of soil and ground water cleanup goals developed for the site?					✓

SETTING

An online database search was conducted to identify reported hazardous materials spills and releases within the Study Area. Environmental databases reviewed include the Department of Toxic Substances Control (DTSC) EnviroStor and the SWRCB GeoTracker. Properties in which historic or on-going activities have resulted in a reported release of hazardous materials into soil and groundwater, as identified by DTSC and SWRCB, are presented in **Appendix L**. These sites are located throughout the City, including within the proposed Project area. It is important to note that listed properties do not necessarily represent a potential risk to the Study Area. Many of the identified sites in the City have been remediated and their cases have been closed.

The EnviroStor database identifies sites that have known contamination or sites for which there may be reasons to investigate further. Specifically, it lists the following site types: Federal Superfund sites (National Priority List [NPL]); State Response, including Military Facilities and State Superfund; Voluntary Cleanup; and School sites. Sites that are in the Hazardous Waste and Substances Site List - Site Cleanup (Cortese List) are also identified. Forty (40) total hazardous material sites were identified by the DTSC EnviroStor database within the proposed Project area (within or adjacent to the proposed pipeline alignments). Of these sites, eleven are considered State Response sites (all certified and in operations and maintenance), nine are considered non-operating (with all closed except one), two are under voluntary cleanup (with both requiring no further action), seven have corrective actions, one is a Federal superfund site (620 Page Mill Road), and ten are considered tiered permit (with one requiring no further action, seven inactive and needing evaluation, and two referred to the RWQCB) (DTSC, 2014a).

The GeoTracker database provides regulatory data regarding sites with leaking underground fuel tanks, fuel pipelines, and public drinking water supplies. A total of 49 hazardous materials sites were identified by the SWRCB Geotracker database within the proposed Project area (adjacent to the proposed pipeline alignments)[15]. Of these sites, 27 sites have been completed and the case closed, 12 sites are open and under remediation, 5 sites are open under remediation with land use restrictions, 1 site is considered open for site assessment, 2 sites are open but inactive, 1 site is open and under assessment and interim remediation, and 1 site is open and under verification monitoring with land use restrictions (SWRCB, 2014).

The Envirostor Hazardous Waste and Substances Site List, which contains a list compiled pursuant to Government Code 65962.5, identifies a site at the corner of Page Mill Road and Porter Drive, which the proposed pipeline alignment would cross (DTSC 2014b). As of 1995 the site status is defined as "certified, operation and maintenance". It consists of approximately 10 acres and has contaminated groundwater resulting from past activities of Hewlett Packard and Kaiser Aerospace and Electronics. The site was

[15] Some of these sites overlap with those shown in the EnviroStor database search results.

originally comprised of three buildings: Building 28A (3155 Porter Drive); Building 28B (1681 Page Mill Road); and Building 28C (1651 Page Mill Road). The proposed pipeline would also pass adjacent to other sites contained on this list (see **Appendix M**).

DISCUSSION

a) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** Operation of the proposed Project would not involve the routine transportation, use, storage, and/or disposal of hazardous materials. However, construction of the proposed Project could temporarily increase the transport of materials generally regarded as hazardous that are used in construction activities. It is anticipated that limited quantities of miscellaneous hazardous substances, such as gasoline, diesel fuel, hydraulic fluids, paint, and other similar materials would be brought onto the Project area, used, and stored during the construction period. The types and quantities of materials to be used could pose a risk to the public and/or the environment. In addition, construction of the proposed Project could result in the exposure of construction workers and residents to potentially contaminated soils due to improper removal of existing hazardous materials on site and/or leakage from the underground storage tanks (USTs) that could potentially be in the area or from other historic releases of hazardous materials to soil or groundwater in the area. The proposed Project includes standard project requirements (proposed as part of the Project) to ensure that hazardous materials would be stored, handled and used in accordance with applicable laws, and contaminated soil and/or groundwater would be disposed of properly. In addition, as part of the proposed Project, a Health and Safety Plan and a Hazardous Materials Management and Spill Prevention and Control Plan would be developed and implemented. Thus, with the implementation of the standard project requirements specified below, potential impacts would be less than significant. No additional mitigation is required.

b) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The construction of the proposed Project could create an additional significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. As with all construction activities, the potential exists for accidents to occur, which could result in the release of hazardous materials into the environment. As discussed in item a) above, hazardous materials would be stored, handled and used in accordance with applicable laws, and contaminated soil and/or groundwater would be disposed of properly. In addition, as part of the proposed Project, a Health and Safety Plan and a Hazardous Materials Management and Spill Prevention and Control Plan would be developed and implemented. With implementation of these standard project requirements proposed as part of the Project, potential impacts would be reduced to less than significant. No additional mitigation is required. Hazardous materials would not be used for operation of the proposed project as described in item a) above.

c) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** A number of schools (El Carmelo Elementary School, Fairmeadow Elementary School, Jane L. Stanford Middle School, Gunn High School, Sunshine Preschool, Sora International Preschool of Palo Alto, Keys School, Grace Lutheran Preschool) are located within one-quarter mile of the proposed pipeline alignment. Only Fairmeadow Elementary School is located adjacent to one of the proposed laterals on East Meadow Drive and Jane L. Stanford Middle School is located in proximity to the same proposed lateral. In addition, other facilities used by children, including Ramos Park, Mitchell Park Community Center and Library, Wilbur Playground, Hoover Park, the soccer fields located on a site previously occupied by Mayfield

School (the school has not existed for 30 plus years) are located along the proposed pipeline alignment, with other parks and a library located within one-quarter mile (Sarah Wallis Park, Weisshaar Park, College Terrace Library, Mayfield Park, and Kite Hill). Although construction activities would require the use of some hazardous materials, due to the short duration and limited extent of construction activity and the implementation of standard project requirements described below, the potential for accidental release of hazardous materials associated with construction activities to affect nearby school children would be reduced to less than significant. No additional mitigation is required.

d) **No Impact.** The project does not propose to construct a school on a property that is subject to hazards from hazardous materials contamination, emissions or accidental release. As a result, no impacts are anticipated and no mitigation is required.

e) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** A search was conducted of the DTSC and SWRCB lists of hazardous materials sites compiled pursuant to Government Code Section 65962.5, as described in the Setting section above. One site is identified on the Hazardous Materials Waste and Substances Site List – Site Cleanup (Cortese List). The proposed pipeline alignment would occur adjacent to or through these hazardous material sites, and thus there is a potential that contamination associated with these sites could be encountered during construction along the public road rights of way. The status of these sites is listed as certified and under operation and maintenance. As described above, a Health and Safety Plan and a Hazardous Materials Management and Spill Prevention and Control Plan would be developed and implemented as part of the proposed Project and an Exceptional Wastewater Permit from RWQCP would be required (standard project requirement). With implementation of these plans and permits, potential impacts are considered to be less than significant.

f) **Less-than-Significant Impact.** The RWQCP is located approximately 1,000 feet south of the Palo Alto Airport. Construction and/or operation of the proposed Project, including the pump station at the RWQCP, would not adversely affect the airport or airport operations, including, noise, take-offs, landings, flight patterns, safety, light, navigation, or communications between aircraft and the control tower within the Project area. The proposed pump station would comply with all requirements of Santa Clara County's Airport Master Plan for the Palo Alto Airport. As a result, no impacts are anticipated and no mitigation is required.

g) **No Impact.** The proposed Project is not located within the vicinity of a private airstrip. As a result, no impacts are anticipated and no mitigation is required.

h) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** During construction, installation of pipelines along roadways could block access to nearby roadways for emergency vehicles. In conjunction with the Traffic Control Plan for the Project, comprehensive strategies for maintaining emergency access shall be developed (see standard project requirements in *Chapter 2, Project Description* and Section E.14 Traffic and Transportation). As part of the emergency access strategies, police, fire, and other emergency service providers would be notified of the timing, location, and duration of construction activities and the location of detours and lane closures. Potential construction-related impacts related to emergency response and evacuation would be reduced to a less-than-significant impact with implementation of the Traffic Control Plan. Once construction is completed, operation of the proposed Project would not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan.

i) **No Impact.** The proposed Project is located within an urban environment and would not be located in an area where there is the risk of wildland fire. Therefore there is no potential to expose people or structures to a significant risk of loss, injury or death involving wildland fires.

j) **No Impact.** The Project would not create a significant hazard to the public or the environment from existing hazardous materials contamination by exposing future occupants or users of the site to contamination in excess of soil and ground water cleanup goals developed for the site. The proposed project consists of a pipeline that would be constructed within existing roadways and/or utility corridors within commercial, industrial, and residential zones within the City, and pump stations located within a park and the RWQCP. These facilities would not house occupants or be used by the general public. As described above, a Health and Safety Plan and a Hazardous Materials Management and Spill Prevention and Control Plan would be developed and implemented as part of the proposed Project. Thus, there would be no impact.

STANDARD PROJECT REQUIREMENTS

Discharge of Exceptional Wastewater

Hydrostatic test water and water collected from dewatering activities (including contaminated water) are discharged to the sanitary sewer with an Exceptional Waste Discharge Permit from RWQCP. The permit requires chemical constituents to be sampled and identifies limits for these constituents. To minimize impacts to water quality, the City shall obtain an Exceptional Wastewater Permit prior to discharge of such waters into the sanitary sewer.

Storage, Handling, and Use of Hazardous Materials in Accordance with Applicable Laws

The City shall ensure that all construction-related hazardous materials and hazardous wastes are stored, handled, and used in a manner consistent with applicable federal, state, and local laws, and the City of Palo Alto's Pollution Prevention plan sheet. In addition, construction-related hazardous materials and hazardous wastes shall be staged and stored away from stream channels and steep banks to keep these materials a safe distance from near-by residents and prevent them from entering surface waters in the event of an accidental release.

Proper Disposal of Contaminated Soil and/or Groundwater

If contaminated soil and/or groundwater is encountered or if suspected contamination is encountered during Project construction, work shall be halted in the area, and the type and extent of the contamination shall be identified. A contingency plan to dispose of any contaminated soil or groundwater would be developed through consultation with appropriate regulatory agencies and consistent with the requirements of the City of Palo Alto's Pollution Prevention plan sheet and RWQCP's permit requirements for discharge of exceptional wastewater to the sanitary sewer.

Health and Safety and Hazardous Materials Management and Spill Prevention Control Plans

The City shall require the contractor to prepare a Health and Safety Plan and Hazardous Materials Management and Spill Prevention and Control Plan prior to commencement of construction that includes a project-specific contingency plan for hazardous materials and waste operations. The Health and Safety Plan shall be applicable to all construction activities, and shall establish policies and procedures according to federal and California Occupational Safety and Health Administration (OSHA) regulations for hazardous materials Health and Safety Plans, and the City of Palo Alto's Pollution Prevention plan sheet.

Elements of the plan shall include, but not be limited to, the following:

- Discussion of hazardous materials management, including delineation of hazardous material storage areas, access and egress routes, waterways, emergency assembly areas, and temporary hazardous waste storage areas;
- Notification and documentation of procedures; and
- Spill control and countermeasures, including employee spill prevention/response training.

Traffic Control Plan

The City's Transportation Section would require the contractor to have a full traffic control plan prepared by a registered traffic engineer. The traffic control plan shall be in accordance with the City's Traffic Control Requirements and would show specific methods for maintaining traffic flows to minimize construction impacts on traffic and parking. There are several schools in the vicinity of the Project. These areas would be evaluated more closely to determine whether the traffic control plan is appropriate or if additional measures are needed specific to school areas. Examples of traffic control measures to be considered include:

- Identify all roadway locations where special construction techniques (e.g., directional drilling) would be used to minimize impacts to traffic flow;
- Develop circulation and detour plans to minimize impacts to local street circulation. This may include the use of signing and flagging to guide vehicles through and/or around the construction zone;
- Schedule truck trips outside of peak morning and evening commute hours;
- Prohibit construction on collector and arterial streets during morning commute period before 9 a.m. and in the afternoon commute period after 4 p.m.;
- Use haul routes, minimizing truck traffic on local roadways to the extent possible;
- Consider detours for bicycles and pedestrians in all areas potentially affected by Project construction. Pedestrian and bicycle detours should not be required unless deemed necessary for safety reasons;
- Use flagmen to maintain alternating one-way traffic while working on one-half of the street;
- Use advance construction signs and other public notices to alert drivers of activity in the area;
- Use "positive guidance" detour signing on alternate access streets to minimize inconvenience to the driving public;
- Install traffic control devices as specified in the California Department of Transportation Manual of Traffic Controls for Construction and Maintenance Work Zones;
- Develop and implement access plans for highly sensitive land uses such as police and fire stations, transit stations, hospitals and schools. The access plans would be developed with the facility owner or administrator. To minimize disruption of emergency vehicle access, ask affected jurisdictions to identify detours, which would then be posted by the contractor. Notify in advance the facility owner or operator of the timing, location, and duration of construction activities and the locations of lane closures;
- Store construction materials only in designated areas; and
- Coordinate with local transit agencies for temporary relocation of routes or bus stops in work zones, as necessary.
- Establish methods for minimizing for construction effects on parking (e.g., identifying designated areas for construction worker parking at staging areas).

MITIGATION MEASURE

No additional mitigation is required.

E.8 LAND USE AND PLANNING

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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) Substantially adversely change the type or intensity of existing or planned land use in the area?					✓
e) Be incompatible with adjacent land uses or with the general character of the surrounding area, including density and building height?					✓
f) Conflict with established residential, recreational, educational, religious, or scientific uses of an area?					✓
g) Convert prime farmland, unique farmland, or farmland of statewide importance (farmland) to non-agricultural use?					✓

SETTING

The Project area is located in the City of Palo Alto, in the northern part of Santa Clara County, primarily west of U.S. Highway 101. The Project area is mostly urban with commercial, residential, and industrial land uses. The Project would pass through a variety of land use designations. The proposed pipeline alignments (backbone and lateral) would traverse primarily land uses designated as Single Family Residential and Research / Office Park as identified in the Palo Alto 1998 – 2010 Comprehensive Plan (City of Palo Alto, 2011). Portions of the pipeline would be located in areas designated as Major Institution

/ Special Facilities (RWQCP). This land use designation provides for institutional, academic, governmental, and community service uses and lands that are either publicly owned or operated as non-profit organizations. The proposed booster pump station would be located at 2700 El Camino Real (Mayfield Soccer Fields) and is designated as Multi-Transit Oriented Residential. The proposed booster pump station would be located within lands that allow such facilities with appropriate use permits. The RWQCP pump station site is designated as Major Institution/Special Facility in the Palo Alto 1998 – 2010 Comprehensive Plan.

The pipeline alignments (backbone and lateral) would pass through a variety of zoning designations, including Research, Office, and Limited Manufacturing District (ROLM), ROLM (E)(D[16])(AD[17]), ROLM (D)(AD), Planned Community (PC), Public Facilities (PF), Single-Family Residence District (R-1), Low Density Multiple-Family Residence District (RM-15), Medium Density Multiple-Family Residence District (RM-30), General Manufacturing District (GM), High Density Multiple-Family Residence District (RM-40), Service Commercial (CS), CS (D), Research Park District (RP), CS, RP-5(D), RP, Residential Estate District (RE) (City of Palo Alto, 2014a and 2014b).

The proposed booster pump station at Mayfield Soccer Fields would be located on land zoned PF with an AS3 Combining Overlay District[18]. The base PF zoning district is designed to accommodate governmental, public utility, educational, and community service or recreational facilities. The proposed booster pump station, a utility facility use, requires a Conditional Use Permit to operate in the PF zoning district. Chapter 18.28 defines the purposes and specifies the applicable regulations and site development standards of special purpose districts, including the PF District. The RWQCP pump station site is zoned PF (D), Public Facilities with a Site and Design overlay.

The Palo Alto Baylands Nature Preserve is located in the vicinity of the proposed Project area; the preserve allows for passive recreational uses such as trails for walking, biking, and bird watching. A small-scale airport operated by the County of Santa Clara (Palo Alto Airport) is located north of the RWQCP.

DISCUSSION

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[16] Site and Design and Review Combining District. The Site and Design Review Combining District regulations are provided in Chapter 18.30(G) of the Zoning Code. The intent of this district is to provide a process for review and approval of development in environmentally and ecologically sensitive areas, including established community areas which may be sensitive to negative aesthetic factors, excess noise, increased traffic or other disruptions, in order to assure that use and development will be harmonious with other uses in the general vicinity, will be compatible with environmental and ecological objectives, and will be in accord with the Palo Alto Comprehensive Plan. Site and design approval must be secured prior to issuance of any permit or other approval for the construction of any building or establishment of any use on any site within the site and design reviewing combining district

[17] Automobile Dealership Combining District.

[18] Alternative Standards Overlay District Three: Community Soccer Fields at Mayfield Site. According to Chapter 18.60, Alternative Development Standards for Stanford Lands, the Alternative Standards Overlay Districts provide alternative development standards for specific sites in order to implement the terms of the 2005 Development Agreement between the City of Palo Alto and Stanford University adopted by Ordinance No. 4870. The purpose of this overlay district is to accommodate the development and use of a community soccer complex on land leased to the City of Palo Alto by Stanford University at the corner of El Camino Real and Page Mill Road on parcels commonly known as 2650, 2700, and 2780 El Camino Real. The land was redistricted from RM (D) Multiple Family Residential to PF Public Facilities in connection with its acquisition for a period of fifty-one years by the City. The modified development standard includes the following :

- Height: lighting standards up to seventy feet high are permitted
- Fencing: Ball-control fencing up to fourteen (14) feet in height is permitted on the site.

a) **Less than Significant Impact.** The proposed Project is located in Santa Clara County, within the City limits of Palo Alto. The proposed pipeline would be constructed underground within existing roadways and/or utility corridors within commercial, industrial, and residential zones within the City. The Mayfield Soccer Fields pump station site is on Stanford property that is leased to the City. The proposed pump station would be up to 1,500 square feet and located on a portion of the parking lot that would not divide existing uses. The proposed pump station at the RWQCP would be located entirely within the existing RWQCP property and integrated with other industrial facilities. The proposed Project would not result in a disruption, physical division, or isolation of existing residential areas or other urban uses. As a result, impacts would be less than significant.

b) **No Impact.** The proposed Project would be constructed on land leased by or owned by the City of Palo Alto, as well as existing road right-of-ways and/or utility corridors within commercial, industrial, and residential zones within the City. The proposed locations for the pump stations are on City owned or leased land in the following zones as defined in the Palo Alto Comprehensive Plan: PF (AS3) (Mayfield Soccer Fields Site) and PF (D) (RWQCP). The project would require Architectural Review / Site and Design review during the design phase to satisfy the requirements of the Architectural Review Board and the City. In addition, a conditional use permit would be required for the booster pump station site. Compliance with these relevant City regulations would ensure that the proposed Project would not conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the Project area. Therefore, no impacts are anticipated and no mitigation is required.

c) **Less than Significant Impact.** The proposed Project would not conflict with the provisions of an adopted Habitat Conservation Plan, Natural Conservation Community Plan, or other approved local, regional, or state habitat conservation plan. The proposed project is within the area covered by the Stanford University HCP, but as discussed evaluation of impacts on biological resources, the measures incorporated in the project are compatible with the HCP.

d,e,f) **No Impact.** The proposed project would not substantially adversely change the type or intensity of existing or planned land use in the area, be incompatible with adjacent land uses or with the general character of the surrounding area, including density and building height, or conflict with established residential, recreational, educational, religious, or scientific uses of an area. As stated above, the proposed Project would be constructed on land leased by or owned by the City of Palo Alto, and within existing roadways and/or utility corridors within commercial, industrial, and residential zones within the City. Pipelines would be located underground. The proposed pump station at the Mayfield Soccer Fields would occupy a small portion of the parking lot and would not affect existing recreational uses. The pump station at the RWQCP would integrate with the other industrial uses on site. For this reason, all existing uses would be maintained and no impacts are expected.

g) **No Impact.** As stated in the Agricultural and Forestry Resources section above, the proposed Project would not 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. The proposed Project would be constructed within existing roadways and/or utility corridors within commercial, industrial, and residential zones within the City or on City owned or leased property. No farming or agriculture takes place within the Project area. As a result, the proposed Project would not affect agricultural practices and/or convert any farmland to non-agricultural usage. No mitigation is required or necessary.

MITIGATION MEASURE

No mitigation is required.

E.9 MINERAL RESOURCES

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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?					✓

SETTING

The proposed Project area is not located on any sites that are identified as a significant source of mineral resources (City of Palo Alto, 2007). Specifically, the proposed Project is not located in an area identified as containing mineral resources classified MRZ-2 by the State geologist that would be of value to the region and the residents of the state. The Palo Alto Comprehensive Plan does not identify any locally important mineral resources or recovery sites in the proposed Project area.

DISCUSSION

a, b) **No Impact.** As the Project area does not contain mineral resources of state, regional or local importance, the proposed Project would not result in the loss of availability of any known mineral resources; therefore, no impact is expected. No mitigation is required.

MITIGATION MEASURE

No mitigation is required.

E.10 NOISE

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?			✓		
b) Exposure of persons to or generation of excessive ground borne vibrations or ground borne 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?			✓		
e) For a project located within an airport land use plan or, where such a plan has not been adopted, 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) Cause the average 24 hour noise level (L_{dn}) to increase by 5.0 decibels (dB) or more in an existing residential area, even if the L_{dn} would remain below 60 dB?			✓		
h) Cause the L_{dn} to increase by 3.0 dB or more in an existing residential area, thereby causing the L_{dn} in the area to exceed 60 dB?			✓		
i) Cause an increase of 3.0 dB or more in an existing residential area where the L_{dn} currently exceeds 60 dB?			✓		
j) Result in indoor noise levels for residential development to exceed an L_{dn} of 45 dB?			✓		

k) Result in instantaneous noise levels of greater than 50 dB in bedrooms or 55 dB in other rooms in areas with an exterior L_{dn} of 60 dB or greater?			✓		
l) Generate construction noise exceeding the daytime background L_{eq} at sensitive receptors by 10 dBA or more?			✓		

SETTING

The proposed Project is located in an urban area consisting of industrial, residential and commercial uses and in the vicinity of a nature preserve. The Palo Alto Comprehensive Plan indicates that major sources of noise throughout the Project area include on-road vehicles, trains, and aircraft. Ambient noise measurements were not taken for the purpose of this EIR. However, according to Map N-3 of the Comprehensive Plan, Noise Exposure Contours, ambient noise levels, measured as L_{dn}[19], in the Project area range from 60 decibels (dBA) in residential, commercial and light industrial areas to 70 dBA along major thoroughfares (e.g., along the Highway 101 Corridor and El Camino Real). Noise levels along Middlefield Road, Page Mill Road, Foothill Expressway and Arastradero Road range from 60 to 65 dBA (City of Palo Alto, 2013). The Comprehensive Plan Update – Noise, Draft Existing Conditions Report presents noise measurements conducted in 2014 at 18 sites throughout the City. One of the monitoring stations (ST-10) is located on East Meadow Drive (near Waverly Street) near one segment of the lateral pipeline. Noise level at this site was measured at 60.6 dBA L_{eq}[20]. This noise monitoring location is considered representative of noise received by residential neighborhoods in the east-central areas of the City (City of Palo Alto, 2014a). The nearest sensitive receptors in the Project area are residences along the proposed pipeline alignment, which are located as close as 50 feet from the work area. The nearest sensitive receptors are located more than 0.5 miles from the RWQCP (to the north) and more than 380 feet from the proposed pump station location at the Mayfield Soccer Fields (to the northeast).

The City of Palo Alto has adopted its own Guidelines for Land Use Compatibility for Community Noise Environments, which guide operational noise based on the land use type. An exterior noise environment up to 60 dBA L_{dn} or Community Noise Equivalent Level (CNEL)[21] is normally acceptable[22] for residential, hotel, motels, schools, libraries, museums, hospitals, personal care, meeting halls, and churches. An exterior noise environment up to 75 L_{dn} or CNEL is considered conditionally acceptable[23] for these same uses. An exterior noise environment up to 65 L_{dn} or CNEL is considered normally acceptable for outdoor sports and

[19] L_{dn} (Day-Night Noise Level): The 24-hour L_{eq} with a 10 dBA "penalty" for noise events that occur during the noise-sensitive hours between 10 pm and 7 am. In other words, 10 dBA is "added" to noise events that occur in the nighttime hours, and this generates a higher reported noise level when determining compliance with noise standards. The L_{dn} attempts to account for the fact that noise during this specific period of time is a potential source of disturbance with respect to normal sleeping hours.
[20] L_{eq} (Equivalent Noise Level): The energy mean (average) noise level. The instantaneous noise levels in dBA during a specific period of time are converted to relative energy values. From the sum of the relative energy values, an average energy value is calculated, which is then converted back to dBA to determine the L_{eq}.
[21] The CNEL is similar to the L_{dn} described above, but with an additional 5 dBA "penalty" for the noise-sensitive hours between 7:00 p.m. to 10:00 p.m., which are typically reserved for relaxation, conversation, reading, and television. If using the same 24-hour noise data, the CNEL is typically about 0.5 dBA higher than the L_{dn}.
[22] Normally acceptable is defined as specified land use is satisfactory, based upon the assumption that any buildings involved are of normal convention, construction, without any special insulation requirements.
[23] Conditionally acceptable is defined as specified land use may be permitted only after detailed analysis of the noise reduction requirements and needed noise insulation features included in the design.

recreation, neighborhood parks and playgrounds. An exterior noise environment up to 75 L_{dn} or CNEL is considered normally acceptable for office buildings, business commercial, professional, industrial, and manufacturing utilities and agriculture (City of Palo Alto, 2007).

For construction, the Palo Alto Municipal Code Chapter 9.10, Noise, states the following: "no individual piece of equipment shall produce a noise level exceeding 110 dBA at a distance of 25 feet. If the device is housed within a structure on the property, the measurement shall be made out-side the structure at a distance as close to 25 feet from the equipment as possible," and "the noise level at any point outside of the property plane of the project shall not exceed one hundred ten dBA." Signage is also required for construction projects describing the construction hours.

The Palo Alto Municipal Code, Chapter 9.10 Noise, sets noise limits for commercial and industrial properties, and states that "[n]o person shall produce, suffer, or allow to be produced by any machine or device, or any combination of same, on commercial or industrial property, a noise level more than eight dB above the local ambient at any point outside of the property plane" (Ord. 4634 § 2 (part), 2000) (a) (City of Palo Alto, 2014b). Policy N-41 of the Palo Alto Comprehensive Plan states that a project should be considered to cause a significant degradation of the noise environment if it would cause the average L_{dn} to increase by 5.0 dB or more in an existing residential area, even if the L_{dn} would remain below 60 dB or if it would cause the L_{dn} to increase by 3.0 dB or more in an existing residential area, where it would cause the L_{dn} to exceed 60 dB or where the L_{dn} currently exceeds 60 dB (City of Palo Alto, 2007).

DISCUSSION

a, c, d, g-l) Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated. The proposed Project has the potential to generate noise during the construction phase through the use of equipment and construction vehicle trips. Construction activities would be temporary in nature, occurring from 8 a.m. to 6 p.m. (9 a.m. to 4 p.m. on arterial and collector streets) Monday through Friday and from 9 a.m. to 6 p.m. on Saturday to comply with both the City's Noise Ordinance and Traffic Control Requirements. Thus, construction-related noise impacts would be short-term. Compliance with the Noise Ordinance would ensure that no individual piece of piece of equipment would produce a noise level exceeding 110 dBA at a distance of 25 feet and that the noise level at any point outside of the property plane of the Project would not exceed 110 dBA.

Peak noise levels generated by most types of construction equipment would be around 80 dBA within 50 feet, although depending on the type of equipment construction activity could produce noise levels in excess of 90 dBA within 50 feet, for short periods of time. Noise levels would fluctuate depending on the particular type, number, and duration of use of various pieces of construction equipment. Back-up beepers associated with trucks and equipment used for material loading and unloading at the staging area would generate significantly increased noise levels over the ambient noise environment in order to be discernable and protect construction worker safety as required by OSHA (29 CFR 1926.601 and 29 CFR 1926.602). Because of the nature of construction (which involves various activities that use a variety equipment during different stages of work), noise levels would be intermittent rather than continuous. In particular, for construction using the open-trench method, noise levels would be concentrated in one area only for limited durations of time, as the pipeline work moves continuously along the alignment. As described in the Project Description, it is estimated that open-trench construction within paved roadways would proceed at a total rate of approximately 200 to 300 feet per day. Assuming a typical property is approximately 50 to 100 feet in width and/or length (depending on the location of the pipeline alignment relative to the homes), construction activities would occur in front of any one home up to a day. Construction using the HDD method would require launch sites or pits, which could occur for one and two weeks at the entry and exit points, respectively. Microtunneling and bore and jack construction would involve longer duration of work because of the excavation, shoring, and dewatering that would be needed. Construction at the pits could range from 6 to 10 weeks depending on the method used. Trenchless construction would be confined to only certain sensitive crossings (see **Table 2-1** in the Chapter 2, Project Description).

Sensitive receptors (residences) in the vicinity of the work areas would be exposed to these elevated noise levels. Construction activities could generate construction noise exceeding the daytime background L_{eq} at sensitive receptors by 10 dBA or more intermittently, as described above, because of certain equipment usage or back-up beepers. However, construction is not anticipated to cause the average 24-hour noise level (L_{dn}) to increase by the 5.0 or 3.0 dBA as specified in the General Plan because of the short-term and intermittent nature of construction noise, restriction of work during the day-time hours, and the continuously moving construction area associated with pipeline construction (if open-construction is used).

In addition, construction equipment noise would be minimized during project construction by muffling and shielding intakes and exhaust on construction equipment and by shrouding or shielding impact tools. All equipment would have sound-control devices no less effective than those provided by the manufacturer. In addition, the City would require in construction specifications that the contractor place all stationary noise generating construction equipment as far away as possible from sensitive receptors or in an orientation minimizing noise impacts (e.g., behind existing barriers or storage piles). Due to the short-term nature of construction activities, the standard project requirements proposed as part of the Project (compliance with the noise ordinance) and the measures specified in **Mitigation Measures NOI-1** and **NOI-2**, potential construction noise impacts associated with the exceedance of background ambient levels would be reduced from potentially significant to less than significant.

Operation of the proposed pipeline and laterals would not degrade the noise environment or create any noise impacts because they do not generate noise. Two pump stations are proposed as part of this project. One would be located in the vicinity (south) of an area zoned for multi-family residential uses and surrounded by an area zoned for research park uses. Another pump station would be located at the RWQCP. Operation of the pump station at Mayfield Soccer Fields would minimally increase ambient noise because it would be located underground. Some noise would be generated from the facility because of the vents that are placed on top of the buried pump station. The nearest sensitive receptors (multi-family residences) are located more than 350 feet northeast of the proposed pump station site, on the north side of El Camino Real. To ensure the proposed pump station complies with the City's noise standards, structure openings, including air ventilation would employ acoustical rated louvers and silencers as appropriate to reduce noise propagation to the outside of the building (see **Mitigation Measure NOI-3**). Because the proposed pump station would be located underground and would be designed to comply with the City's noise standards (see also the standard project requirement proposed as part of this Project), operation of the pump station would not degrade the noise environment or expose sensitive receptors to noise levels above the City's noise standards.

Motor noise from the proposed pump station at the RWQCP would be negligible given the existing ambient noise from other facilities already in operation at the site and the distance from sensitive receptors. Compliance with the Palo Alto Municipal Code and Noise Ordinance and design of the pump station to meet the City's noise standards (see **Mitigation Measure NOI-3**) would ensure that impacts related to operational noise are less-than-significant.

Based on the analysis above and with implementation of standard project requirements and **Mitigation Measures NOI-1** through **NOI-3**, the proposed Project would not expose people to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards.

b) **Less-than-Significant Impact.** Operation of the proposed Project would not generate excessive groundborne vibration or noise impacts. Construction of the proposed Project could likely result in minor and temporary increases in groundborne vibration or noise, however, construction activities would be temporary as described above. Compliance with the Palo Alto Municipal Code and Noise Ordinance and design of the pump stations to meet the City's noise standards would ensure that impacts associated with the exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels would be less than significant.

e) **Less-than-Significant Impact.** The Palo Alto Airport is located across Embarcadero Road from the RWQCP. The existing airport noise exposure at the RWQCP would remain unchanged. There are no residences in the area of the RWQCP pump station site and workers at the Project area are not expected to be exposed to excessive noise levels from airport noise that is any different from current conditions. As a result, the impact would be less than significant and no specific mitigation is required.

f) **No Impact.** The Project is not located within the immediate vicinity of a private airstrip and would not affect any aircraft operations. No impact is expected.

STANDARD PROJECT REQUIREMENTS

Compliance with Local Noise Ordinance

According to the City of Palo Alto's Noise Ordinance (Palo Alto Municipal Code Chapter 9.10), for residential and non-residential property, construction, alteration and repair activities which are authorized by a valid city building permit shall be prohibited on Sundays and holidays and shall be prohibited except between the hours of 8:00 a.m. and 6:00 p.m. Monday through Friday, and 9:00 a.m. and 6:00 p.m. on Saturday, provided that the construction, demolition or repair activities during those hours meet the following standards:

- No individual piece of equipment shall produce a noise level exceeding 110 dBA at a distance of 25 feet. If the device is housed within a structure on the property, the measurement shall be made outside the structure at a distance as close to 25 feet from the equipment as possible.
- The noise level at any point outside of the property plane of the Project shall not exceed 110 dBA.
- The holder of a valid construction permit for a construction project in a non-residential zone shall post a sign at all entrances to the construction site upon commencement of construction, for the purpose of informing all contractors and subcontractors, their employees, agents, materialmen and all other persons at the construction site, of the basic requirements of this measure[24].
    - The sign(s) shall be posted at least five feet above ground level, and shall be of a white background, with black lettering, which lettering shall be a minimum of one and one-half inches in height.
    - The sign shall read as follows:

[24] This would be applicable at the pump station sites and not along the pipeline due to the nature of pipeline construction.

CONSTRUCTION HOURS

FOR RESIDENTIAL (OR NON-RESIDENTIAL) PROPERTY

(Includes Any and All Deliveries)

MONDAY - FRIDAY........8:00 a.m. to 6:00 p.m.

SATURDAY.........9:00 a.m. to 6:00 p.m.

SUNDAY/HOLIDAYS........Construction prohibited.

Pump Station Design/Noise

For the pump station at the Mayfield Soccer Fields, a detailed analysis of the buildings' sound isolation would be conducted by a qualified acoustical consultant during the engineering design phase of the project. A post-construction field sound measurement shall be conducted by an acoustical consultant to verify that the project operational noise standards are in compliance with relevant City noise standards.

MITIGATION MEASURES

Mitigation Measure NOI-1: Noise Control Measures to Reduce Construction Noise. Noise Control Measures to Reduce Construction Noise. The City shall incorporate into contract specifications r all of the following measures:

- Impact equipment (e.g., jack hammers, pavement breakers, and rock drills) used for project construction will be hydraulically or electrically powered whenever possible to avoid noise associated with compressed air exhaust from pneumatically powered tools. However, where use of pneumatically powered tools is unavoidable, an exhaust muffler on the compressed air exhaust would be used. This muffler can lower noise levels from the exhaust by up to 10 dBA. External jackets on the tools themselves would be used where feasible, and this could achieve a reduction of 5 dBA. Quieter procedures will be used such as drilling rather than impact equipment whenever feasible.
- Wherever possible, sonic or vibratory pile drivers will be used instead of impact pile drivers. If sonic or vibratory pile drivers are not feasible, acoustical enclosures will be provided as necessary to reduce noise levels. Engine and pneumatic exhaust controls on pile drivers will be required as necessary to ensure that exhaust noise from pile driver engines are minimized to the extent feasible. Where feasible, pile holes will be pre-drilled to reduce potential noise and vibration impacts.
- All equipment and trucks used for project construction shall use the best available noise control techniques (including mufflers, use of intake silencers, ducts, engine enclosures and acoustically attenuating shields or shrouds) and be maintained in good operating condition to minimize construction noise impacts. All internal combustion engine-drive equipment shall be fitted with intake and exhaust mufflers which are in good condition.
- Unnecessary idling of internal combustion engines shall be prohibited. In practice, this would mean turning off equipment if it would not be used for five or more minutes.
- Stationary noise-generating construction equipment, such as air compressors and generators, shall be located as far as possible from homes and businesses.
- Staging areas shall be located as far as feasibly possible from sensitive receptors.

Mitigation Measure NOI-2: Pre-Construction Notification. Prior to construction, written notification to residents within 500 feet of the proposed facilities undergoing construction shall be provided, identifying the type, duration, and frequency of construction activities. Notification materials shall also identify a mechanism for residents to register complaints with the City if construction related noise impacts should occur.

Mitigation Measure NOI-3: Design of the Pump Station to Reduce Noise. To ensure the proposed pump station complies with the City's noise standards, structure openings, including air ventilation would employ acoustical rated louvers, silencers, or other noise-reduction devices, as appropriate, to reduce noise propagation to the outside of the building.

E.11 POPULATION AND HOUSING

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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) Create a substantial imbalance between employed residents and jobs?					✓
e) Cumulatively exceed regional or local population projections?					✓

DISCUSSION

a-e) **No Impact.** The proposed Project is in response to a need to improve water supply management and reliability, and protect San Francisco Bay by reducing the discharge of wastewater that could impact the sensitive Bay environment. The proposed Project would not displace existing housing, involve construction of new housing, create imbalance between employed residents and jobs, or exceed regional or local population projections. As a result, the proposed Project is anticipated to have no impacts on population and housing. No mitigation is required.

MITIGATION MEASURE

No mitigation is required.

E.12 PUBLIC SERVICES

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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?					✓

DISCUSSION

a-e) **No Impact.** The proposed Project would not change the existing demands for public services (e.g., fire and police protection, schools, parks) as it would neither add housing, people, nor jobs. The Project is in response to a need to improve water supply management and reliability, and protect San Francisco Bay by reducing the discharge of wastewater that could impact the sensitive Bay environment. As a result, the proposed Project is anticipated to have no impacts on public services. No mitigation is required.

MITIGATION MEASURE

No mitigation is required.

E.13 RECREATION

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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?					✓
c) Does the project affect recreational facilities?				✓	

SETTING

The proposed pipeline would be located primarily within road rights-of way in the City of Palo Alto and would pass by several parks, including Ramos Park, Mitchell Park, and Wilbur Playground off East Meadow Drive, Hoover Park off Cowper Street, and Mayfield Soccer Fields off Page Mill Road. The proposed pump station would be located within the parking spaces of the Mayfield Soccer Fields. The Option 1 pipeline would traverse Adobe Creek Pedestrian Path underneath Highway 101, the entry point to the Adobe Creek Loop Trail (Bay Trail) on the east side of Highway 101. The Adobe Creek Pedestrian Path is used by both bicyclists and pedestrians, and is closed October 15th through April 15th. Trails are within the RWQCP, generally along the north and east portion of the plant parallel to Embarcadero Road, away from the proposed pump station (City of Palo Alto, 2014). One of the proposed booster pump stations would be located at the Mayfield Soccer Fields, within existing parking spaces.

DISCUSSION

a-b) **No Impact.** The proposed Project would not change the existing demands on recreational facilities. The Project is in response to a need to improve water supply management and reliability, and protect San Francisco Bay by reducing the discharge of wastewater that could impact the sensitive Bay environment. Parking for recreation at Mayfield Soccer Fields would be temporarily impacted by construction activities in the parking lot where the underground pump station would be located (see the discussion in Transportation and Traffic below). However, construction would be temporary and recreation activities on the fields would not be impacted. The use of existing recreational facilities in the vicinity of the RWQCP would not be impacted by the proposed project, as the pump station would comply with the requirements of the Baylands Master Plan. As a result, the proposed Project is anticipated to have no impacts.

c) **Less than Significant Impact.** The Option 1 segment would require the temporary closure of the Adobe Creek Pedestrian Path during construction while hanging the pipeline from the bridge. Construction would last a maximum of two weeks, in which time users would be unable to access this crossing of Highway 101. As discussed above, the Adobe Pedestrian Path is the gateway to the Adobe Creek Loop Trail that rings the Palo Alto Baylands Nature Preserve, which connects to other trails within the Bay Trail system. The Adobe Creek Pedestrian Path under the highway typically closes during the rainy season, and users connect to the Adobe Creek Loop Trail via other routes. Due to the temporary duration anticipated for the closure of this facility, and because users are accustomed to seasonal closures of this path and can cross Highway 101 from alternate routes (e.g., through City streets to the north at the Embarcadero Road Overpass parallel to the Oregon Expressway off ramp), impacts to existing recreational uses are considered less than significant. Thus, no mitigation is required.

The proposed pump station would be located in the vicinity of the trails within the RWQCP parallel to Embarcadero Road. Construction may require crossing this trail if the connection pipeline is needed. Direct impacts include closure of the trail temporarily during construction of the connection pipeline. Due to the temporary nature of construction across the trail (no more than a couple of days), potential impacts would be less than significant.

MITIGATION MEASURES:

No mitigation is required.

E.14 TRANSPORTATION AND TRAFFIC

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Exceed the capacity of the existing circulation system, based on an applicable measure of effectiveness (as designated in a general plan policy, ordinance, etc.), taking into account all 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 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 that impacts traffic circulation and air quality?			✓		
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., pedestrian, transit & bicycle facilities)?			✓		
h) Cause a local (City of Palo Alto) intersection to deteriorate below Level of Service (LOS) D and cause an increase in the average stopped delay for the critical movements by four seconds or more and the critical volume/capacity ratio (V/C) value to increase by 0.01 or more?				✓	
i) Cause a local intersection already operating at LOS E or F to deteriorate in the average stopped delay for the critical movements by four seconds or more?				✓	
j) Cause a regional intersection to deteriorate from an LOS E or better to LOS F or cause critical movement delay at such an intersection already operating at LOS F to increase by four seconds or more and the critical V/C value to increase by 0.01 or more?				✓	
k) Cause a freeway segment to operate at LOS F or contribute traffic in excess of 1% of segment capacity to a freeway segment already operating at LOS F?				✓	

l) Cause any change in traffic that would increase the Traffic Infusion on Residential Environment (TIRE) index by 0.1 or more?				✓	
m) Cause queuing impacts based on a comparative analysis between the design queue length and the available queue storage capacity? Queuing impacts include, but are not limited to, spillback queues at project access locations; queues at turn lanes at intersections that block through traffic; queues at lane drops; queues at one intersection that extend back to impact other intersections, and spillback queues on ramps.				✓	
n) Impede the development or function of planned pedestrian or bicycle facilities?			✓		
o) Impede the operation of a transit system as a result of congestion?			✓		
p) Create an operational safety hazard?					✓

SETTING

The proposed project would be located primarily within City street rights-of-way. There are two highways within the Project area, Highway 101 and El Camino Real. The proposed pipeline would cross under Highway 101 and a small portion of El Camino Real. Option 2 would traverse El Camino Real between Oregon Expressway and Hansen Way. The other project segments occur on local, collector, and arterial streets.[25] Traffic counts were not taken for the purpose of this EIR. However, traffic volumes are reported on Map T-7 of the Comprehensive Plan, for existing conditions (1993-1995) and for the projected 2010 Project. Given the lack of more updated traffic volumes available for the City, the projected 2010 daily traffic volumes are used to characterize the existing conditions for this project. The daily traffic volumes for roadways within the Project area are shown below:

- Highway 101 between Oregon Expressway and San Antonio Road: 201,600
- East Meadow Drive at Grove Avenue: 5,100
- Alma Street at El Dorado: 39,400
- El Camino Real between Page Mill Road and Portage Avenue: 61,800
- Page Mill Road, below Porter Drive: 32,600

The Comprehensive General Plan Update Transportation and Traffic Draft Existing Conditions Report identifies the traffic volumes on two streets within the proposed Project area (City of Palo Alto, 2014).

[25] Local streets are defined as minor roadways that provide access to adjacent properties only. Collector streets are roadways that collect and distribute local traffic to and from arterial streets, and provide access to adjacent properties. Arterial streets are major roadways primarily serving through traffic, and takes traffic to and from expressways and freeways, along with providing access to adjacent properties (Palo Alto Comprehensive Plan Update Draft Existing Conditions Report, Transportation and Traffic).

- Page Mill Road, between I-280 and El Camino Real has a daily capacity of 35,000 and an ADT of 34,204. The LOS is F.
- Alma Road, between University Avenue and San Antonio Road has a daily capacity of 31,700 and an ADT of 28,475. The LOS is E.

An LOS analysis conducted for certain intersections in the City under existing conditions (March/April 2014) showed that the following intersections are operating at acceptable LOS during the AM and PM peak hour:

- El Camino Real and Page Mill Road/Oregon Expressway
- Page Mill Road and Foothill Expressway
- Foothill Expressway & Arastradero Road

The Valley Transportation Authority (VTA), the Congestion Management Agency (CMA) for Santa Clara County, prepared the 2013 Congestion Management Plan (CMP 2013) (SCVTA, 2013). The 2013 CMP identifies the CMP roadway network, which includes all state highways and principal arterials[26]. Within the Project area, the following roadways and intersections are part of the CMP network:

- Highway 101
- Highway 82 (El Camino Real)
- Page Mill Road/Oregon Expressway

CMP intersections occur at Page Mill Road/Oregon Expressway at El Camino Real and Page Mill Road at Foothill Expressway. The CMP also identifies a CMP transit network; the Grid Bus Route that passes Highway 82 traverses the Project area. Grid routes form the backbone of VTA's bus network and are typically mainline routes that operate along major corridors and serve the urbanized areas of Santa Clara Valley. Line 22, a grid line, provides the highest ridership line in the bus system, and provides east-west service along El Camino Real in the Project area. The VTA also identifies cross county bicycle corridors; four corridors occur within the Project area:

- Corridor 2: Alma Street/Caltrain Corridor from San Mateo County to Santa County
- Corridor 3: Dumbarton – East / West Connector Corridor from North Palo Alto to Los Altos (includes Oregon Expressway and Page Mill Road)
- Corridor 4: El Camino – Grand Boulevard Corridor from San Mateo County to Downtown San Jose
- Corridor 5: Shoreline – Miramonte / El Monte Corridor from Mountain View to Los Altos (includes Arastradero Road)

The CMP also identifies the level of service of CMP network roads during the AM and PM peak periods. Highway 101 from Oregon Expressway south operates at LOS E and F in the north and south directions, respectively during the AM peak period. Both directions operate at LOS F in the PM peak period. Highway 280 (south of the Project area) operates at LOS C near Page Mill Road during the AM peak period, and C to F at the same locations during the PM peak periods.

[26] VTA defines urban arterials as roadways that connect with the freeway and/or county expressway system and principal arterials. To be classified as a principal arterial the road must meet one of the following criteria: 1) State highway; 2) six-lane facility; or 3) non-residential arterial with average daily traffic (ADT) of 30,000 vehicles per day or greater.

VTA and SamTrans provide bus service and Stanford University provides shuttle bus service within the City. Bus and shuttle lines occur throughout the Project area, including the following (SamTrans, 2014; Stanford University, 2014):

- Stanford Marguerite Shuttle buses traverse Page Mill Road, El Camino Real, Porter Drive, Hillview Avenue, Arastradero Road, Deer Creek Drive, and Foothill Expressway
- VTA bus line 35 traverses Middlefield Road
- VTA bus line 88 traverses East Meadow Drive, Miranda Avenue
- VTA bus line 89 traverses Hansen Road Hanover Street, Hillview Avenue, and Miranda Avenue
- VTA bus lines 101, 102, and 103 traverse El Camino, Page Mill Road, Hansen Road Hanover Street, and Hillview Avenue
- VTA bus line 104 traverses Alma Street, Hanover Streets, Hillview Avenue, and Miranda Avenue
- SamTrans bus line KX traverses El Camino Real, Page Mill Road, Porter Drive and Hanover Street

Based on the Mid-Peninsula Bicycle Map for East Palo Alto, Menlo Park, Palo Alto, and Stanford, the following streets contain Class II bike lanes[27]: East Bayshore Road, Fabian Way, East Meadow Drive, Middlefield Road, Cowper Street (between East Meadow Drive and Loma Verde Avenue), Page Mill Road, Hansen Way, Hanover Street, Porter Drive, and Hillview Avenue. The segment of Cowper Street between Loma Verde Avenue and Oregon Expressway and Oregon Expressway between Park Boulevard and El Camino Real contain Class III bike routes (Stanford University, 2009)[28] .

As described in *Chapter 2, Project Description*, the proposed project would generate up to 16 truck trips (round trips) per day associated with the hauling of spoil and imported material and delivery of material and equipment if open-trench construction and trenchless construction using microtunneling were to occur at sensitive crossings[29]. In addition to the truck hauling/material delivery trips, up to 30 worker trips (round trips) would be generated per day (20 trips during the peak commute period and 10 trips during the middle of the day for lunch). Thus, the total truck trips generated per day would be 46 trips per day[30]. While all of the trips associated with workers traveling to and from work would occur during the peak hours (20 trips each in the morning and afternoon), the majority of the truck trips would be spread throughout the day. Construction of the proposed project would occur from 8 a.m. to 6 p.m. (9 a.m. to 4 p.m. only on arterial and collector streets). Assuming 16 truck trips are evenly spread throughout the 9 hour workday (Monday – Friday), about 2 truck trips would occur per hour. According to the Santa Clara Valley Transportation Agency’s Congestion Management Program, the morning and evening peak periods occur from 5 to 9 a.m. and 3 to 7 p.m. Construction would overlap four hours of the peak traffic periods. Assuming 2 truck trips per hour, the total vehicle trips during the peak morning period would be approximately 22 (2 truck trips and 20 passenger trips); the total vehicle trips during the peak afternoon period would be 26 (6 truck trips and 20 passenger trips). Sixteen truck trips throughout a day are assumed for a conservative analysis.

[27] Class II bike lanes are streets with bike lanes.
[28] Class III bike routes are defined as streets that are well-suited for bicycling but do not have bike lanes.
[29] The number of truck trips would be less if the HDD method were implemented. Specifically, HDD would generate approximately 3 truck trips per day if material and equipment delivery is included.
[30] Please see *Chapter 2, Project Description*, for more information on vehicle assumptions associated with the proposed project. These assumptions are conservative to provide the worst case scenario.

Realistically, no more than 10 truck trips would likely occur in a day for a project of this size, based on the duration needed for loading and unloading trucks and driving to and from a site.[31]

Two highways are located within the Project area: Highway 101 and Highway 82 (El Camino Real). Project construction would cross under both facilities using trenchless construction techniques. Thus, neither of these facilities would be affected directly. Option 2 includes an alignment within a small segment of Highway 82, where construction work hours would be shortened (from 9 am and 4 pm Monday through Friday to maintain compliance with the City's Traffic Control Requirements). Construction could occur either using open-trench techniques or HDD, which would avoid surface traffic impacts. Trucks would traverse the Project area during work hours, and trucks and worker vehicles would use the on- and-off ramps of nearby highways (Highway 101 and Highway 280).

DISCUSSION

This analysis assumes open trench construction on roadways with trenchless construction at sensitive crossings. If HDD is implemented where open trench construction would occur, anticipated effects would be less than specified below as areas of lane closures would be less than that for open trench construction and the work areas would be smaller than those for microtunneling.

Pipeline installation activities would temporarily disrupt transportation and circulation patterns in the vicinity of the Project. **Table 2-1** shows roadways affected by the project and construction methods at roadway crossings. The Project could significantly affect roadway segments and intersections on all pipeline segments if the construction zone were to reduce the travel width during peak traffic periods. Potential conflicts between construction traffic and bicyclists and pedestrians could occur along the major pipeline route as well as along the lateral routes. Traffic is generally heavy along Alma Street and Page Mill Road. The intersection of Oregon Expressway/Page Mill Road and El Camino Real is a major traffic intersection, as is the intersection of Hillview Avenue and Foothill Expressway. Temporary effects on traffic could increase the potential for accidents, affect emergency access, displace on-street parking, and disrupt transit service. The City has a practice of imposing a 5-year moratorium on cutting newly paved streets, with appropriate exceptions. No trench work would occur on streets that have been paved within the 5 years prior to construction unless an agreement can be reached to allow for the exception. The implementation of a Traffic Control Plan, which is a standard project requirement, and implementation of the mitigation measures identified below would ensure that all traffic impacts are mitigated to a less-than-significant level.

The proposed project is anticipated to generate less than 50 net new peak-hour construction-related vehicle trips, which is below the City's threshold for requiring a focused traffic analysis, and less that than the local CMA's threshold for a detailed traffic impact analysis (100 trips). Based on the relatively low traffic generation estimates, the project is not anticipated to result in significant peak hour or daily traffic impacts. No new trips would be generated for operation

a,b) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The proposed alignment and alignment options would be installed within roadway rights-of-way using standard open-cut trenching techniques by means of speed shoring or trench box bracing. Traffic-generating construction activities related to pipeline installation would consist of the daily arrival and departure of construction workers at the work site; trucks hauling equipment and materials to the work site daily; and the hauling of excavated spoil from, and import of new fill to, each work site. Based on the estimated crew size, and assuming some

[31] Typically, for construction projects of this scale, only a total of 10 truck hauling trips would occur per day (spread over the entire day) due to the time it takes to load and unload trucks and for travel back and forth from the landfill.

overlap in construction activities at the work site, the proposed Project would generate approximately 46 construction-related vehicle trips as described above. This would not be substantial relative to background traffic conditions. Project-generated trips would fall within the daily fluctuations of traffic volumes for nearby roadways. Therefore, this short-term increase in vehicle trips would not significantly affect level of service and traffic flow on roadways.

Pipeline construction would typically require a minimum of one lane of traffic and the adjacent shoulder, resulting in a construction corridor approximately 20 to 30 feet wide. It is expected that open trench construction within paved roadways would proceed at the rate of up to 150 feet per day for each construction crew, with an overall work zone of up to 300 feet in length per day. Typical roadway excavations encompass a single lane and part of the shoulder and/or bike lane, should they exist, although full road closures may be required along narrower streets (e.g., El Dorado and Cowper streets). However, impacts would be relatively brief at any one location along the pipeline alignment, at most a few days.

The City of Palo Alto would repair any damage to the road due to construction. The City has a practice of imposing a 5-year moratorium on cutting newly paved streets, with appropriate exceptions. No trench work would occur on streets that have been paved within the 5 years prior to construction unless an agreement can be reached to allow for that exception.

The proposed pipeline would be constructed within and/or cross several roadways. The exact placement of the pipeline in the roadways is not known at this time, but regardless of where it would be installed, pipeline installation activities would temporarily disrupt existing transportation and circulation patterns in the vicinity. Impacts would include direct disruption of traffic flows and street operations. Pipeline installation would result in a reduction in travel lanes and on-street parking. Pipe installation work within and/or across high traffic volume arterials could significantly affect traffic flow and operation at these locations. The Project would affect roadway segments and intersections on the pipeline alignment during construction. Implementing the traffic control plan (a standard project requirement proposed as part of the Project), limiting construction to off-peak times (see standard project requirement and **Mitigation Measure TRA-1**), and returning roads to pre-construction conditions (see standard project requirements described in Chapter 2, Project Description) would ensure that traffic impacts are less than significant. There are several schools in the vicinity of the Project (see Section E.7, Hazards and Hazardous Materials for these locations). These areas would be looked at more closely to determine whether the traffic control plan is appropriate or if additional measures are needed specific to school areas.

c) **No Impact.** The proposed Project does not involve use of air transit, nor is it expected to cause any change in air traffic patterns. No impact is expected and no mitigation is required.

d) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The Project would not change the configuration (alignment) of area roadways. However, heavy equipment operating adjacent to or within road right-of-way would increase the risk of accidents, as could the increased congestion resulting from lane and/or road closures. Potential conflicts also could occur between construction traffic and bicyclists and pedestrians and there is also potential for an increase in accidents resulting from limited lines of sight due to construction.

As a standard project requirement of the proposed Project, the contractor is required to prepare and implement a traffic control plan in accordance with professional engineering standards prior to construction, including compliance with roadside safety protocols, so as to reduce the risk of accident. Specific requirements that may be included in the traffic control plan are identified below. Thus, implementation of the traffic control plan would ensure temporary increases in the potential for accidents would be less than significant. Standard project requirements would ensure that roads are returned to their pre-construction condition or better. There are several schools in the vicinity of the Project. These areas would be looked at more closely to determine whether the Traffic Control Plan is appropriate or if additional measures are needed specific to school areas.

e) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The proposed Project would have temporary effects on traffic flow due to lane/road closures and added truck traffic during construction, which could result in delays for emergency vehicle access in the vicinity of the Project or restriction of access to adjacent land uses. In addition, The City's fire station 2 is located on Hanover Street at the corner of Page Mill Road, adjacent to one segment of the proposed lateral pipeline. Through the development of the traffic control plan and comprehensive strategies for maintaining emergency access (proposed as a standard project requirement of the proposed Project), the contractor would establish methods for maintaining traffic flow in the Project vicinity and minimizing disruption to emergency vehicle access along the construction route. If proper detours are not provided for streets that may require closure during construction activities, significant impacts could occur. Identification of detours, developed as part of the traffic control plan and emergency access strategies would ensure that traffic impacts are less than significant.

There are several schools in the vicinity of the Project. These areas would be looked at more closely to determine whether the traffic control plan is appropriate or if additional measures are needed specific to school areas.

f) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The proposed Project would create limited new, temporary parking demand for construction workers and construction vehicles as the crew moves along the installation alignment. The Project would not require a substantial number of construction workers along the construction alignment (2 crews of 10 workers each at each construction area); therefore, the number of parking spaces required would not be substantial. If certain alignment options are selected, existing on-street parking may be temporarily displaced. However, given the proposed rate of new pipe installation (up to 150 feet per day in each construction area for a maximum of up to 300 feet per day), impacts to on-street parking would be relatively brief at any one location along the alignment.

Some parking at the Mayfield Soccer Fields would be temporarily lost due to the construction activities in the parking lot where the underground pump station would be located. The construction area would be fenced off from the rest of the parking area for safety and security purposes and would not be usable during construction. In the long-term, there could be the loss of up to two spaces at the parking area because of the need for an access hatch to be located above the buried pump station and other appurtenances that may be located above ground at the site. Because disruption during construction would be of limited duration and up to two parking spaces are projected to be lost permanently (out of the 91 existing spaces, or about 2 percent), this impact would be considered less than significant. The City's Utilities Department would work with the Parks and Recreation division to ensure coordination of construction activities to minimize loss of parking at the Mayfield Soccer Fields.

If Option 1 of the backbone pipeline is implemented, pits associated with trenchless construction could be placed within parking lots of commercial areas adjacent to Fabian Way and East Bayshore Road, on the west and east side of Highway 101. During construction, these spaces would be temporarily lost, potentially disrupting business operations. However, due to the presence of other parking in the area, and with **Mitigation Measure TRA-2** (coordination with businesses on the location and timing of construction), potential impacts would be reduced to less than significant.

Construction of the proposed pump station at the RWQCP would create a temporary parking demand for construction workers and construction vehicles at the plant. The RWQCP can provide sufficient parking spaces for construction projects.

Through development of the traffic control plan, the construction contractor would establish methods for minimizing construction effects on parking. Specific requirements that may be included in the traffic control plan are identified below, under standard project requirements. Implementation of the traffic control plan would ensure potential impacts associated with potential temporary displacement of parking would further reduce less-than-significant impacts. There are several schools in the vicinity of the Project. These areas would be looked at more closely to determine whether the traffic control plan is appropriate or if additional measures are needed specific to school areas.

g) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** The proposed Project would not conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., pedestrian, transit & bicycle facilities) as it would not have any long-term impacts on alternative transportation facilities. Construction could temporarily impact bicycle and pedestrian routes/paths during construction (see item n below) and buses accessing bus stops along the proposed construction corridor (see item o below). However, these facilities would be restored to pre-project conditions (see standard project requirements) after construction activities are complete. Thus, with the standard project requirements proposed as part of the proposed Project to address temporary effects, no long term impacts would occur, impacts are considered less than significant and no additional mitigation measures are required.

h-m) **Less-than-Significant Impact.** As stated in checklist item a,b) above, traffic-generating construction activities related to pipeline installation would consist of the daily arrival and departure of construction workers at the work site; trucks hauling equipment and materials to the work site daily; and the hauling of excavated spoil from, and import of new fill to, each work site. Each pipeline construction crew would consist of an estimated 10 workers. Construction equipment used for pipeline construction would include backhoes, front-end loaders, dump trucks, flatbed delivery trucks, cranes, compactors, concrete trucks, and paving equipment. Based on the estimated crew size (two crews of 10 people each), and assuming some overlap in construction activities at the work site, construction worker trips traveling to and from the work site are not anticipated to exceed 30 round trips per day (20 during the peak traffic hours and 10 during the midday). The total number of off-site construction truck trips would be approximately 16 round trips per work day. These trips include material (pipes) delivery, fuel shipments, and maintenance trucks. This would not be substantial relative to background traffic conditions. Project-generated trips would fall within the daily fluctuations of traffic volumes for nearby roadways. Therefore, this short-term increase in vehicle trips would not significantly affect level of service and traffic flow on roadways.

The Project would affect roadway segments and intersections on the pipeline alignment during construction. Limiting construction to off-peak times and implementing a traffic control plan, proposed as a standard project requirement as part of the Project, would ensure that traffic impacts are less than significant. There are several schools in the vicinity of the Project. These areas would be looked at more closely to determine whether the Traffic Control Plan is appropriate or if additional measures are needed specific to school areas. Refer to checklist item a,b) above for additional discussion.

n) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** Bicycle paths are located along the proposed pipeline route. The proposed Project would not permanently impede the development or function of planned pedestrian or bicycle facilities. The proposed Project would have temporary effects due to lane / pedestrian path closures during construction, which could result in detours for pedestrian and bicycle flow and use of temporary facilities in the vicinity of the Project during the construction period. Through the development of the traffic control plan (proposed as part of the project as a standard project requirement), the contractor would establish methods for maintaining pedestrian and bicycle facilities in the Project vicinity and minimizing disruption to these facilities along the construction route (see also Section E.13, Recreation, for potential effects on the existing Adobe Creek Pedestrian Trail). Implementation of the Traffic Control Plan would also ensure potential impacts associated with temporary effects on planned pedestrian and bicycle facilities would be less than significant as all roadways would be restored to their original configuration upon completion of the project (see standard project requirements). There are several schools in the vicinity of the Project (see Section E.7, Hazards and Hazardous Materials, for the location of these schools). These areas would be looked at more closely to determine whether the Traffic Control Plan is appropriate or if additional measures are needed specific to pedestrian and bicycle facilities near school areas.

o) **Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated.** Several bus/shuttle lines traverse the Project area and multiple bus/shuttle stops are located along the proposed pipeline route. Construction-related effects on transit services, such as slower bus movements around the construction zone and temporarily relocation of bus stops could occur. However, up to 300 feet of roadways per day would be affected during construction activities, limiting the area of impact on transit services. Bus stops would be temporarily relocated and signs would be posted at the existing and temporary bus stops. Given the proposed rate of new pipe installation and extent of the affected area, and because all roadways would be restored to their original configuration upon completion of the project (see standard project requirements), impacts to transit services would be considered less than significant.

p) **No Impact.** The proposed Project would not create an operational safety risk as it would not permanently alter the configuration of any project roadways. Thus, no impact would occur and no mitigation is required.

STANDARD PROJECT REQUIREMENT

Traffic Control Plan

The City's Transportation Section would require the contractor to have a full traffic control plan prepared by a registered traffic engineer. The traffic control plan shall be in accordance with the City's Traffic Control Requirements and would show specific methods for maintaining traffic flows to minimize construction impacts on traffic and parking. There are several schools in the vicinity of the Project. These areas would be evaluated more closely to determine whether the traffic control plan is appropriate or if additional measures are needed specific to school areas. Examples of traffic control measures to be considered include:

- Identify all roadway locations where special construction techniques (e.g., directional drilling) would be used to minimize impacts to traffic flow;
- Develop circulation and detour plans to minimize impacts to local street circulation. This may include the use of signing and flagging to guide vehicles through and/or around the construction zone;
- Schedule truck trips outside of peak morning and evening commute hours;
- Prohibit construction on collector and arterial streets during morning commute period before 9 a.m. and in the afternoon commute period after 4 p.m.;
- Use haul routes, minimizing truck traffic on local roadways to the extent possible;
- Consider detours for bicycles and pedestrians in all areas potentially affected by Project construction. Pedestrian and bicycle detours should not be required unless deemed necessary for safety reasons;
- Use flagmen to maintain alternating one-way traffic while working on one-half of the street;
- Use advance construction signs and other public notices to alert drivers of activity in the area;
- Use “positive guidance” detour signing on alternate access streets to minimize inconvenience to the driving public;
- Install traffic control devices as specified in the California Department of Transportation Manual of Traffic Controls for Construction and Maintenance Work Zones;
- Develop and implement access plans for highly sensitive land uses such as police and fire stations, transit stations, hospitals and schools. The access plans would be developed with the facility owner or administrator. To minimize disruption of emergency vehicle access, ask affected jurisdictions to identify detours, which would then be posted by the contractor. Notify in advance the facility owner or operator of the timing, location, and duration of construction activities and the locations of lane closures;
- Store construction materials only in designated areas; and
- Coordinate with local transit agencies for temporary relocation of routes or bus stops in work zones, as necessary.
- Establish methods for minimizing for construction effects on parking (e.g., identifying designated areas for construction worker parking at staging areas).

Restoration of Roads to Pre-construction Condition

Following construction, the City shall ensure that road surfaces, bicycle routes, and bus stop facilities that are damaged during construction are returned to their pre-construction condition or better.

MITIGATION MEASURES

With the incorporation of the following mitigation measures, potential temporary impacts are considered to be less than significant.

Mitigation Measure TRA-1: CMP Facilities

The City shall work with VTA to determine when peak hour traffic starts on Page Mill Road, a CMP facility. If peak hour traffic starts around 3 p.m. on this road, then the City shall prohibit construction on this roadway after 3 p.m.

Mitigation Measure TRA-2: Coordinate construction with Businesses.

To reduce the disruption of business from the temporary reduction of parking, the City shall coordinate with individual businesses on the timing of construction.

E.15 UTILITIES AND SERVICE SYSTEMS

Issues and Supporting Information Resources Would the project:	Sources	Potentially Significant Issues	Potentially Significant Unless Standard Project Requirements / Mitigation Incorporated	Less Than Significant Impact	No Impact
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 inadequate 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 federal, state, and local statutes and regulations related to solid waste?				✓	
h) Result in a substantial physical deterioration of a public facility due to increased use as a result of the project?				✓	

SETTING

Project operation would not result in any exceedance of wastewater treatment requirements, because the use of recycled water would be in accordance with Title 22 and Order No. 93-160 Water Reclamation Requirements for the City of Palo Alto RWQCP for use of recycled water. The project would include construction of an underground pump station at the Mayfield Soccer Fields site and a pump station at the RWQCP, but would not increase the need for additional off-site storm water drainage facilities. No wastewater would be generated, so no impacts would occur concerning the regional wastewater treatment facilities. No long-term waste generation would be associated with the Project, and the construction contractor would be required to comply with all pertinent regulations regarding the disposal of solid waste.

DISCUSSION

a) **Less than Significant Impact.** The Project is limited to construction and operation of a recycled water pipeline, an associated booster pump station, and a pump station at the RWQCP. Pipeline and pump station operation and use of recycled water would be in accordance with Title 22 and the RWQCB-issued Waste Discharge Requirements for use of recycled water, which would detail any wastewater treatment and monitoring requirements. Therefore, Project implementation would not result in any exceedance of wastewater treatment requirements and impacts would be considered less than significant.

b) **No Impact.** The proposed Project consists of distribution pipelines, an associated booster pump station, and a pump station at the RWQCP. The Project is proposed in order to provide for the beneficial use of recycled water within the City of Palo Alto and provides benefits to both wastewater and water resources management, through provision of a disposal mechanism and providing a reliable irrigation supply source. Thus, the proposed Project would not require or result in the construction of any new water or wastewater treatment facilities or expansion of existing recycled water facilities beyond what is evaluated in this EIR. The evaluation of potential impacts of this project is provided in **Chapter 3** and this appendix to the EIR.

c) **Less-than-Significant Impact.** Ground cover above distribution pipelines would be restored to pre-existing conditions and the proposed pump stations would be located under or on existing paved areas, where stormwater is already captured by existing storm drains. In addition, the use and amount of irrigation water would not increase due to change in source of water, so the proposed Project would not generate new sources of stormwater. Therefore, the Project would not increase the need for additional off-site storm water drainage facilities, whose construction could cause significant environmental effects. Thus, no impact would occur and no mitigation is required.

d) **No Impact.** The proposed Project is a recycled water project consisting of distribution facilities and associated pump stations and does not require any entitlements. As such, no impact would occur and no mitigation is required.

e) **No Impact.** The proposed Project is a recycled water project consisting of distribution facilities and associated pump stations and would not generate wastewater for treatment. Therefore, it would not require any wastewater treatment capacity and no impact would occur. No mitigation is required.

f) **Less-than-Significant Impact.** Solid waste generation would be limited to construction activities associated with the generation of trash by workers, and would not affect available solid waste disposal capacity in the region. No long-term solid waste generation would be associated with the Project. Thus, impacts would be less than significant and no mitigation is required.

g) **Less than Significant Impact.** The contractor would be required to comply with all pertinent regulations regarding the disposal of solid waste generated by construction activities; therefore, impacts would be less than significant and no mitigation is required.

h) **Less than Significant Impact.** The proposed Project would not result in a substantial physical deterioration of a public facility due to increased use. The proposed Project is limited to operation of recycled water distribution facilities and associated pump stations that would provide recycled water for irrigation of private and public landscaped areas. The project would replace existing potable water supplies with recycled water, and provide a sustainable source of water even during dry hydrologic years. Therefore, no impacts would occur and no mitigation is required.

MITIGATION MEASURE

No mitigation is required

Appendix F – RWQCP Partners Salinity Reduction Resolutions

Resolution No. 9035

Resolution of the Council of the City of Palo Alto Establishing a Salinity Reduction Policy for Recycled Water

WHEREAS, the Regional Water Quality Control Plant (RWQCP) serves the Cities of Palo Alto, Los Altos, and Mountain View, the East Palo Alto Sanitary District, the Town of Los Altos Hills and Stanford University; and

WHEREAS, the City of Palo Alto currently uses tertiary treated wastewater from the RWQCP to irrigate the Palo Alto Municipal Golf Course, Greer Park, the Emily Renzel Marsh and portions of the Palo Alto Duck Pond; and

WHEREAS, the City of Mountain View, a RWQCP partner, will begin delivering recycled water from the RWQCP to end users in Mountain View in Summer 2010; and

WHEREAS, the City of Palo Alto is investigating an expansion of the recycled water delivery system to serve predominantly irrigation customers within the Stanford Research Park; and

WHEREAS, although regulatory limits for Total Dissolved Solids (TDS, a common measure of the salinity in a water system) do not exist, recycled water from the RWQCP contains higher than expected TDS levels compared to the average potable source water concentrations of the RWQCP partners; and

WHEREAS, the establishment of a quantitative TDS goal based on elimination of saltwater infiltration from the Baylands will assist the RWQCP's efforts to reduce the TDS level to a level one would expect given the RWQCP partners' source water; and

WHEREAS, City of Palo Alto, as managing partner of the RWQCP and in partnership with the other RWQCP partners, has developed a Recycled Water Salinity Reduction Policy to identify and pursue all cost effective measures to reduce the salinity of the recycled water over time.

NOW, THEREFORE, the City Council of the City of Palo Alto does hereby RESOLVE as follows:

SECTION 1. The Council approves the Recycled Water Salinity Reduction Policy, attached as Exhibit A.

SECTION 2. The Council authorizes City Utilities Department and RWQCP staff to coordinate implementation of the Recycled Water Salinity Policy with the RWQCP partners

SECTION 3. The Council directs City staff to submit biannual progress reports to Council on the effort to reduce the Total Dissolved Solids levels in the RWQCP's recycled water.

SECTION 4. In compliance with the CEQA, Council finds that the approval of the Salinity Reduction Policy is not a "project" under CEQA, because the Policy does not involve any commitment to a specific project which may result in a potentially significant physical impact on the environment, as contemplated by Title 14, California Code of Regulations, Section 15378(b)(4).

INTRODUCED AND PASSED: January 25, 2010

AYES: BURT, ESPINOSA, KLEIN, PRICE, SCHARFF, SCHMID, SHEPHERD

NOES: HOLMAN, YEH

ABSENT:

ABSTENTIONS:

ATTEST:

City Clerk

APPROVED:

Mayor

APPROVED AS TO FORM:

Deputy City Attorney

City Manager

100128 syn 6051045

EXHIBIT A

CITY OF PALO ALTO
RECYCLED WATER SALINITY REDUCTION POLICY

POLICY STATEMENT

Recycling treated wastewater is increasing in the arid West as a response to the fact that populations are increasing and fresh water supplies are not. Palo Alto and other communities are using treated wastewater for landscape irrigation and that use is expected to grow dramatically in the future. Salts accumulate in water when it is used by people and industrial processes. To maximize the use of recycled water on the widest variety of green plants, the salt content (salinity) needs to be minimized. The purpose of this policy is to ensure that the City is taking all practical steps to reduce salinity in recycled water.

Therefore, it shall be the policy of Palo Alto to prevent unnecessary additions of salt to the sewer system, with a goal of lowering the Total Dissolved Solids (TDS) in the recycled water to less than 600 parts per million (PPM).

Applicability of this Policy

Palo Alto shall utilize this policy and its 600 PPM Total Dissolved Solids (TDS) goal to develop salinity control measures. Palo Alto owns and operates the Regional Water Quality Control Plant (RWQCP), which treats wastewater from Palo Alto and five other communities. The RWQCP Partners, including Palo Alto, will be asked to identify controllable salt inputs to wastewater from their communities and to implement control measures.

PROCEDURES

Staff estimates that the wastewater TDS can be reduced to 600 PPM without modifying normal human use or industrial activities. The major way in which salts can be reduced is by controlling the infiltration of saline groundwater which is currently entering sewer pipes through cracks and problem areas in those pipes as they cross saline areas near San Francisco Bay. Other sources of controllable salt must also be explored.

The activities that will be completed to implement this policy include:

1. Determine the salinity levels for each entity whose wastewater is treated by the RWQCP.
2. Identify the sources of salinity.
3. Develop alternatives for reducing the salinity levels.
4. Identity the actions that can be implemented to meet the TDS goal.
5. Prepare Salinity Reduction Plan.
6. Monitor TDS and report to Council semi-annually on progress towards meeting the TDS goal.
7. Monitor impact of Total Dissolved Solids (TDS) and all the relevant constituents of concern for salinity on compost, plants and soil.

Note: Questions and/or clarifications of this policy should be directed to the Public Works Department.

EAST PALO ALTO SANITARY DISTRICT

Resolution No. 992

RESOLUTION ESTABLISHING A SALINITY REDUCTION POLICY FOR RECYCLED WATER

WHEREAS, the Regional Water Quality Control Plant ("RWQCP") serves the Cities of Palo Alto, Los Altos and Mountain View, the East Palo Alto Sanitary District ("District"), the Town of Los Altos Hills and Stanford University (collectively, the "RWQCP Partners");

WHEREAS, as population growth and drought cycles continue to impact the availability of potable water supplies in the arid west, communities are increasingly turning to treated wastewater (recycled water) for landscape irrigation and other urban uses;

WHEREAS, lowering the salinity of wastewater to the maximum extent practical will make the recycled water more desirable and decrease the need to employ expensive management and technical practices;

WHEREAS, although regulatory limits for Total Dissolved Solids ("TDS"), a common measure of the salinity in a water system, do not exist, recycled water from the RWQCP contains higher than expected TDS levels compared to the average potable source water concentrations of the RWQCP Partners;

WHEREAS, the establishment of a quantitative TDS goal based on elimination of saltwater infiltration from the Baylands will assist the RWQCP's efforts to reduce the TDS level to a level one would expect given the RWQCP Partners' source water; and

WHEREAS, the RWQCP Partners, have developed a Recycled Water Salinity Reduction Policy to identify and pursue all cost effective measures to reduce the salinity of the RWQCP Partners' recycled water over time.

NOW, THEREFORE, the Board of Directors of the East Palo Alto Sanitary District ("Board") hereby finds and orders as follows:

Section 1. The Board approves the Recycled Water Salinity Reduction Policy, attached hereto as Exhibit A.

Section 2. The Board authorizes District Staff to coordinate implementation of the Recycled Water Salinity Policy with the RWQCP Partners.

Section 3. The Board directs District Staff to submit biannual progress reports to the Board on the effort to reduce the TDS levels in the RWQCP's recycled water.

Section 4. In compliance with CEQA, the Board finds that the approval of the

Recycled Water Salinity Reduction Policy is not a "project" under CEQA, because the Policy does not involve any commitment to a specific project which may result in a potentially significant impact on the environment, as contemplated by Title 14, California Code of Regulations, Section 15378(b)(4).

Passed and adopted by the District Board of the East Palo Alto Sanitary District at a Regular Board Meeting thereof held on the 1st day of April 2010, by the following vote:

Ayes: and in favor thereof, Members : J. Sykes-Miessi, G. Mitchell, B. Yanez, G. Savage
D. Scherzer

Noes: Members:

Abstain: Members:

Absent: Members:

President of the District Board of the
East Palo Alto Sanitary District of
San Mateo County, State of California

Attest:

Secretary of the District Board of the
East Palo Alto Sanitary District of
San Mateo County, State of California

(SEAL)

ORANGE\MDONNELLY\65051.2

RESOLUTION NO. 2011-06

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF LOS ALTOS SUPPORTING THE CITY OF PALO ALTO'S RECYCLED WATER SALINITY REDUCTION POLICY

WHEREAS, City of Palo Alto, as managing partner of the Regional Water Quality Control Plant (RWQCP) and in partnership with the other RWQCP partners, has developed a Recycled Water Salinity Reduction Policy to identify and pursue all cost effective measures to reduce the salinity of the recycled water over time; and

WHEREAS, said policy shall provide guidelines to help establish a quantitative Total Dissolved Solids (TDS) goal for the City of Los Altos based on the saltwater infiltration research and testing done by City of Palo Alto which will assist in the RWQCP's overall efforts to reduce the TDS level to a level expected given the City of Los Altos' source water.

NOW THEREFORE, BE IT RESOLVED, that the City Council of the City of Los Altos hereby finds and authorizes the following:

> Support the City of Palo Alto's Recycled Water Salinity Reduction Policy to prevent unnecessary additions of salts to the sewer system with a goal of lowering the TDS in the recycled water to less than 600 parts per million (PPM).

I HEREBY CERTIFY that the foregoing is a true and correct copy of a Resolution passed and adopted by the City Council of the City of Los Altos at a meeting thereof on the 22nd day of February 2011 by the following vote:

AYES:	SATTERLEE, CARPENTER, FISHPAW, PACKARD
NOES:	NONE
ABSENT:	CASAS
ABSTAIN:	NONE

Ronald D. Packard, MAYOR

Attest:

Susan Kitchens, CITY CLERK

CERTIFIED AS A TRUE COPY

City Clerk, City of Los Altos, CA

COUNCIL REPORT

CITY OF MOUNTAIN VIEW

AGENDA: May 11, 2010

4.7

CATEGORY: Consent

DEPT.: Public Works

TITLE: Approve Recycled Water Salinity Reduction Policy

RECOMMENDATION

Approve the Regional Water Quality Control Plant salt reduction policy.

FISCAL IMPACT

Approval of the recommended policy has no direct fiscal impact, although repairs to the City's sanitary sewer collection system may be required to meet the policy. Staff anticipates minor repairs can be funded from existing annual sanitary sewer capital improvement projects. Costs for major repairs or replacements will be developed as sources of salt infiltration are identified, and projects will be included in the Capital Improvement Program (CIP) for Council's consideration.

BACKGROUND AND ANALYSIS

In 2009, the Cities of Mountain View and Palo Alto completed construction of the recycled water pipeline from the Regional Water Quality Control Plant (RWQCP) in Palo Alto to the North Bayshore Area. The salt content of the recycled water is relatively high (approximately 900 parts per million (ppm)) and can harm some landscaping, including redwood trees. Salt enters the wastewater stream from a number of sources, including human and commercial/ industrial activities, infiltration of salty groundwater into the sewer pipes near the Bay, groundwater extraction systems that legally discharge into the sewer, water softeners and illegal sewer connections. Salt content of no more than 600 ppm is desirable for landscape irrigation purposes. Attachment 1 provides additional information regarding salt in the recycled water produced by the RWQCP and efforts to address the issue.

To maximize use of the recycled water, staff from Mountain View and Palo Alto have been working together to develop and implement a long-term strategy to reduce the salt concentration of the wastewater stream and recycled water. Part of the strategy is adoption of a salinity reduction policy. The City of Palo Alto adopted the policy on January 25, 2010 and requested that all partner agencies do the same. Partner agencies include Mountain View, Los Altos, East Palo Alto Sanitary District and Stanford. The recommended policy (Attachment 2) has the following major elements:

- Set a goal of reducing salinity in recycled water to 600 ppm.
- Determine salinity levels in the waste stream from each partner agency.
- Identify sources of salinity.
- Develop alternatives for reducing salinity.
- Identify actions that can be implemented to meet salinity goal.
- Prepare a Salinity Reduction Plan.
- Monitor salinity and report progress semiannually.

Staff believes that intrusion of salty groundwater near the Bay into sewer pipes is a major source of salinity in the waste stream and is already working with Palo Alto staff to install salt monitors at key locations in the sewer collection system (Attachment 3). Video inspection of sewer lines is planned where salt intrusion is suspected or indicated by monitoring results. Mountain View has also redirected discharge of pumped groundwater at the landfill from the sanitary sewer to Stevens and Permanente Creeks.

Adoption of the Salinity Reduction Policy will formalize the actions the City is already taking to reduce salinity in the recycled water and set a uniform goal among the partner agencies. If groundwater intrusion is confirmed, projects to repair the sewer lines will be included in the City's CIP. Minor repairs can be accomplished with the annual sewer main replacement projects that are already included in the CIP, while more significant repairs would be proposed as separate projects.

The proposed policy does not set deadlines for reducing salinity or meeting the 600 ppm target, but semiannual progress reports are required. If the policy is approved, staff plans to continue investigating groundwater intrusion and other sources of salt in the wastewater stream and develop cost estimates for repairs. Staff will include repair projects as appropriate in the CIP where Council will have discretion regarding the funding and timing of the projects.

PUBLIC NOTICING – Agenda posting.

Prepared by:

David Serge
Utilities Services Manager

Approved by:

Michael A. Fuller
Public Works Director

Kevin C. Duggan
City Manager

DS/GAH/7/CAM
761-05-11-10M-E^

Attachments:
1. February 11, 2010 Salt Mitigation Strategies Memorandum (without Attachment)
2. Salinity Reduction Policy
3. Map of Salt Monitoring Locations

cc: City of Palo Alto

Attachment 1

CITY OF MOUNTAIN VIEW
MEMORANDUM

DATE: February 11, 2010

TO: Kevin C. Duggan, City Manager
Michael A. Fuller, Interim Public Works Director

FROM: Gregg A. Hosfeldt, Assistant Public Works Director

SUBJECT: RECYCLED WATER—SALT MITIGATION STRATEGIES

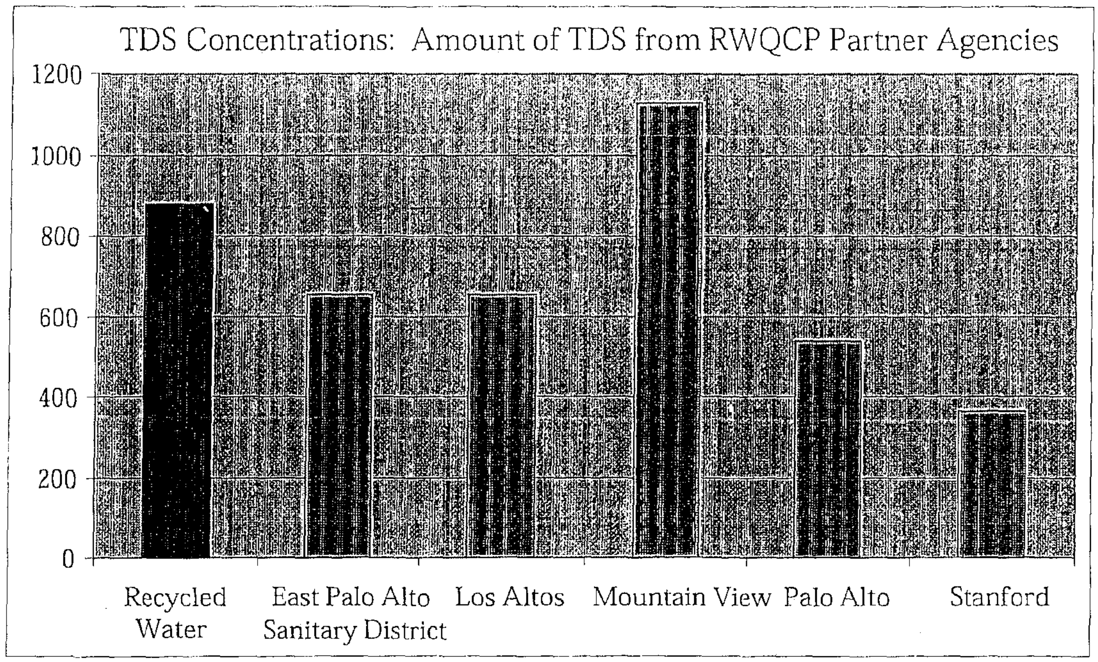
In 2009, the Cities of Mountain View and Palo Alto completed construction of a recycled water pipeline from the Regional Water Quality Control Plant (RWQCP) in Palo Alto to the North Bayshore Area. Recycled water provides a droughtproof supply for City facilities and North Bayshore business, saving fresh water for potable and environmental needs, and reducing fresh water flows to the San Francisco Bay from the RWQCP.

Because the high salt content of recycled water can harm some plants, including redwood trees, staff from Mountain View and Palo Alto have been working together to develop and implement a long-term strategy to reduce the salt concentration of the wastewater stream and recycled water.

Salinity Identification and Mitigation

Salt enters the wastewater system from numerous sources, including human and commercial/industrial activities, infiltration of salty groundwater near the Bay into underground pipes, groundwater extraction systems that legally discharge to the sewer, water softeners and illegal sewer connections.

Salt is expressed in terms of Total Dissolved Solids (TDS) and measured in parts per million (p.p.m.); the chart below shows the sources of wastewater and the salt content received by the RWQCP. The wastewater stream from Mountain View contains the highest salinity levels of the partner agencies, and the TDS of recycled water generally ranges between 880 p.p.m. and 1,000 p.p.m.



The RWQCP partners have established a goal of reducing TDS to approximately 600 p.p.m. In an effort to reduce TDS, in 2009 Mountain View and RWQCP staff began a monitoring program to identify the primary sources of salinity. The first phase of monitoring has not identified the source of the high salt content of Mountain View's wastewater stream, and extensive testing is planned for 2010.

While monitoring to locate the sources of salinity has been inconclusive, in recent months two significant sources of salt were eliminated.

- Palo Alto lined approximately 0.25 mile of a sewer main between the RWQCP and the Palo Alto Interpretive Center to reduce groundwater intrusion from pipe defects and abandoned services. These actions corrected problems identified through testing performed in the City of Palo Alto.

- Mountain View extracts groundwater from three landfill sites to lower groundwater levels and prevent water intrusion into closed landfill cells. This groundwater, which is high in TDS because it is close to the Bay, was historically discharged to the sanitary sewer. In December, after receiving approval from the Regional Water Quality Control Board (Board), the water was rerouted to Permanente Creek and Stevens Creek. Staff worked with the Board and the

RWQCP to perform extensive testing to ensure the groundwater was safe for discharge to the creeks.

Mountain View's Fire and Environmental Protection Division is also monitoring the TDS of groundwater discharged to the sewer from permitted groundwater remediation operations. TDS monitoring was added to the discharge permit requirements to ensure that groundwater quality would not significantly impact the quality of recycled water produced at the RWQCP.

Next Steps

On January 25, 2010, the Palo Alto City Council adopted a policy to reduce recycled water TDS levels to 600 p.p.m. (Attachment 1). The policy includes statements regarding actions necessary to identify and mitigate sources of salt, and the RWQCP partners are currently developing a detailed monitoring plan to identify and reduce sources of salt from all agencies. The RWQCP will also soon request that the partner agencies formally adopt the attached policy.

The TDS reductions generated by recent efforts have been less than anticipated, and it is clear more comprehensive monitoring is necessary to reduce TDS to an acceptable level. The monitoring effort will continue for the next 6 to 12 months, after which Mountain View and Palo Alto will develop a strategy to continue reducing the salt content of the recycled water through system rehabilitation and repairs, and, if necessary, water treatment. Anticipated steps in the salinity monitoring phase include:

- Monitoring salinity levels at the RWQCP and at the outflow of Mountain View's Sewage Pump Station (near the golf course pro shop) to determine the salinity increase resulting from groundwater infiltration in the main sewer pipeline. The pipeline runs from the Sewage Pump Station, under the golf course on the south side of Shoreline Sailing Lake and along Casey Avenue to a metering station on San Antonio Road. This portion of the pipeline is owned by Mountain View, which will be responsible for necessary repairs or replacement.

  The RWQCP will also perform extensive monitoring of the pipeline between the metering station and the treatment plant. Because the pipeline is located in bay mud, staff believes that significant infiltration may be the cause of the high salt content of Mountain View's wastewater. This portion of the pipeline is owned by the RWQCP, and necessary repairs will likely be the responsibility of the RWQCP partners. If large amounts of infiltration are identified, staff will develop pipeline repair and replacement options, but repairing or replacing the pipeline will be a complex and expensive project requiring significant environmental study.

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Appendix G – Evaluation of Use of Recycled Water for Landscape Irrigation

Evaluation of Use of Recycled Water for Landscape Irrigation

Palo Alto Recycled Water Project
Phase 3

Prepared for:
RMC Water and Environment
222 Sutter Street, Suite 700
San Francisco, CA 94108

Prepared by:
HortScience, Inc.
2150 Rheem Dr., Suite A
Pleasanton, CA 94588

and

Kelley and Associates Environmental Science
20 E. Baker Street
Winters, California 95694

June 13, 2011

HORT SCIENCE

Evaluation of Use of Recycled Water for Landscape Irrigation
Palo Alto Recycled Water Project, Phase 3
Palo Alto, CA

Executive Summary

RMC Water and Environment is preparing an Environmental Impact Report for the Palo Alto Recycled Water Project, Phase 3. The project site is located in the Stanford Research Park area. HortScience, Inc. was asked to contribute to that effort by performing site evaluations and assessing the potential effects of irrigation with the project recycled water on the existing landscapes.

Site selection and evaluation

To evaluate the potential response of landscapes to the RWQCP recycled water, we selected seven properties located on the primary mapped soil units within the area and having a range in landscape types. At each property we investigated the soil characteristics at one to three sites for a total of 13 sites. At each site we hand-excavated the soil using a 3 ¼ inch auger to depths of 18" to 60". The soil profile was described in terms of texture, structure, layers, moisture, and presence of roots. Twenty-six soil samples were collected at various depths within the profile for chemical analysis.

Plant species vary in their tolerance to salts. At each property we identified the plant taxa present and described the general condition of the plants (good, fair, poor). In addition we estimated the relative frequency of occurrence of the taxon in the landscape (common throughout landscape, occasionally present within the landscape, one to a few plants present).

For each plant taxon we estimated its salt tolerance (high, moderate, low) based on information available in the literature and our experience with the species in landscapes irrigated with recycled water and potable waters having similar salt concentrations.

Anticipated response of landscapes

Landscape response to irrigation with recycled water depends on the degree to which soil will become affected and the tolerance of plant materials to salts and specific ions. To determine the effects, water, plant, site characteristics, and irrigation management must be considered (Table i).

RWCQP water quality

In evaluating the likely landscape responses to the recycled water we considered the maximum and mean concentrations of total salts, boron, sodium, chloride, pH, and the calculated value for adjusted sodium adsorption ratio (data Nov. 2008 – Aug. 2010 provided by City of Palo Alto).

Table i: Summary of landscape conditions and expected response to irrigation with RWQCP recycled water. City of Palo Alto

Property	Landscape description	Plant palette salt tolerance (% of all taxa at property)				Soil conditions	Soil suitability for recycled water	Expected landscape response
		High	Moderate	Low	Unknown			
Theranos 3200 Hillview	Predominately drought tolerant plants managed with low irrigation; planted during redevelopment; mature pines retained.	38%	46%	10%	6%	Surface compacted, layered silty clay soil; parking lot island with fine sandy loam fill over native clay.	Problematic due to clay subsoil.	Minimal adverse effects expected to drought tolerant plants on low irrigation regimes. Low percentage of landscape expected to exhibit salt damage.
VM Ware 3401 Hillview	Mix of water demand from low to high; mature redwoods and pines retained during redevelopment; native oaks in non-irrigated area.	41%	34%	21%	4%	Surface compacted, gravelly clay	Problematic where clay subsoil is strong; moderate across rest of site.	Minimal adverse effects expected to majority of landscape. Redwoods and other salt sensitive species are expected to decline due to excess salt.
Clocktower 600-660 Hansen Way	Mature landscape, predominately moderate to high water requiring plants including redwoods.	23%	39%	35%	3%	Layered clays and gravelly clays, surface compacted.	Poor due to high clay content and possible high water table.	Substantial adverse effects expected due to high percentage of taxa having low and moderate salt tolerance and limited ability to leach accumulated salts from root zone. No notable change to taxa with high salt tolerance expected.
Mitchell Park 600 East Meadow Drive.	Mature landscape; wide range of species with varying water requirements; mature redwoods.	35%	45%	19%	1%	Deep clays.	Poor due to clay of surface and subsoil.	Substantial adverse effects expected due to high percentage of taxa having low and moderate salt tolerance and limited ability to leach accumulated salts from root zone. Effects on turf expected to be minimal if recommendations for soil management employed. No notable change to taxa with high salt tolerance expected.

Table i, continued: Summary of landscape conditions and expected response to irrigation with RWQCP recycled water. City of Palo Alto

Property	Landscape description	Plant palette salt tolerance (% of all taxa at property)				Soil conditions	Soil suitability for recycled water	Expected landscape response
		High	Moderate	Low	Unknown			
Terman Park 695 Arastradero Rd.	Mature landscape; predominately turf. Plants at adjacent school included in inventory.	36%	36%	25%	3%	Deep gravelly clays, surface compacted	Moderately suitable; good drainage.	Minimal effects expected because site is predominately turf and soils can be leached.
Hewlett Packard, 3000 Hanover St.	Mature landscape; wide range of species with varying water requirements; mature redwoods; native oaks.	39%	35%	20%	6%	Deep gravelly clays, surface compacted	Moderately suitable in uplands; problematic in lower landscape positions.	Substantial effects expected to plants in lower landscape positions, including mature redwoods. No notable change in taxa with high salt tolerance expected.
Tesla Motors, 3500 Deer Creek Rd.	Recently renovated; wide range of species with varying water requirements; mature perimeter landscapes retained; native oaks.	45%	42%	13%	0%	Layered gravelly clays and clay loams, surface compacted.	Moderately suitable; good drainage.	Minimal effects expected to drought tolerant plants on low irrigation regimes. Low percentage of landscape expected to exhibit salt damage.

At its current mineral content, the RWQCP recycled water presents a moderate salinity hazard for landscape irrigation based on reported maximum and mean electrical conductivity (Ec_w), chloride and sodium concentrations. Boron, pH and SAR are not limiting to landscapes. Anticipated effects include the following:

- Nitrates in the water will enhance plant growth and reduce need for applied fertilizers to maintain the landscape.

- Gradual increase in soil salinity is expected. Water salt concentrations are at levels that are likely to damage sensitive plant species. Damage may occur to moderately tolerant species where salts accumulate in the soil over several years of irrigation.

- Gradual increase in soil sodium adsorption ratio (SAR) is expected. Decrease in soil permeability may occur with prolonged use.

Soil conditions

Soils across the project area varied with landscape position and were generally variable with depth, even on the same property. Soils were generally fine in texture: silt loam, silty clay loam, clay loam, and clay. Gravels were common; presence of large gravels restricted sampling depth at some sites. Imported fill soils were present atop old landscape surfaces at sites.

The chemical composition of the soils with regard to salts (Ec_e, Cl, Na, B, SAR) was similar. In all samples the salt concentrations were low and within the range of tolerance of salt sensitive plants. Soil pH was more variable, ranging from 5.5 (acidic) to 8.0 (alkaline). Average pH was 7.0 (neutral), which is optimum for most landscape plants.

The variability of the soil profiles with regard to texture, structure, and stratification, can present problems for plant growth, root penetration, and water and gas exchange. To prevent salts from accumulating in the root zone, soils must be permeable enough to allow water (bearing salts in solution) to move through the profile, and the salt-laden waters must be able to move through and out of the root zone. Where soils are layered, barriers to these processes occur.

Some generalizations about soil compatibility with irrigation applications follow:

- Because many of the lowland soils are very fine-textured (clays or clay loams) and in some cases overlie even finer textured layers, restrictions to water infiltration and leaching of root zone profiles is expected. These soils could be actively managed to allow appropriate leaching of salts and removal of saline leachate with the installation of extensive drainage infrastructure.
- Soils of the uplands (hillslopes and terraces) are generally gravelly and of somewhat coarser texture and underlain by gravelly strata. These soils probably can be managed to prevent excessive salt concentrations in the root zones because sufficient leaching fractions can be applied and drainage is adequate. These soils will require active monitoring if recycled waters are applied.

Plant sensitivity to salts

Plants have a threshold for salt tolerance. Reaching that threshold depends on the initial salt concentration in soil, the degree to which salt accumulates under a given irrigation regime, the degree to which the plant is under physiological stress from heat, water deficit, and air pollution, soil conditions (depth, texture, structure, drainage), and the presence of other biotic problems such as insects and diseases.

In total, 227 taxa were identified at the seven properties. Overall the landscapes appeared attractive and healthy, with some exceptions where irrigation was not adequate for plant needs and where mature plants had been damaged during construction.

Principal plant taxa were identified based on frequency of occurrence and number of sites in which they occurred. Principal plants were taxa that were classified as 'common' in one or more properties, and 'several' in two or more properties. Annual plants were excluded. Of the 227 taxa, 98 (43%) are principal plants.

Salt tolerance rankings are as follows:

- 35% (42 % of principal plants) have high salt tolerance. These plants are expected to maintain good appearance and health with appropriate irrigation with RWQCP recycled water.
- 39% (36% of principal plants) have moderate salt tolerance. These plants are expected to develop symptoms of salt stress when irrigated with current RWQCP recycled water, especially in poorly drained soils. These plants may show some damage, but appearance will likely be acceptable when viewed from several feet away. Regular and thorough leaching will be required to maintain these plants.
- 21% (17% of principal plants) had low salt tolerance. Foliage damage to these plants is likely to be obvious and degrade plant appearance. It is unlikely that leaching treatments using current recycled water would be adequate to prevent plant damage.
- For 5% there is no information in the literature about salt tolerance, and we have no experience with the species in landscapes irrigated with recycled water.
- We do not anticipate notable changes to turf quality with introduction of recycled water as long as soil salinity and sodicity is managed. Turf often responds positively to the nutrient elements provided by recycled water. Fertilizer applications should be reduced when recycled water is applied.

Recommendations for recycled water use at Palo Alto

1. RWQCP recycled water at its current mineral content could be used as an irrigation source with changes in landscape management to monitor and react to increases in soil salinity and by replacing low salt tolerant plants with species having high salt tolerance. On lowland soils it may be necessary to replace some moderately salt tolerant species if appearance becomes unacceptable, and to install sub-drain systems to remove saline leachate.
2. The salinity hazard could be reduced if the recycled water quality was improved to maintain TDS below 1,000, Ec_w below 1500 µmohs/cm, chloride below 200 mg/l, and sodium below 150 mg/l. The salinity hazard could be eliminated if the recycled water quality was improved to maintain TDS below 650 mg/l, Ec_w below 1000 µmohs/cm, chloride below 100 mg/l, and sodium below 70 mg/l.
3. Monitor soil salinity and SAR through periodic soil analyses, preferably taken early, midway, and late in the irrigation season (approximately April, July, and October). The results of these analyses will guide the leaching and gypsum programs.

4. To avoid plant damage to salt sensitive landscape plants, implement a leaching program to maintain soil salinity within the root zone below 2.0 dS/m and SAR below 6.0. However, it is unlikely that soil salinity can be maintained below this level unless potable water is used for leaching. For moderately salt-tolerant plants, maintain soil salinity below 4.0 dS/m. Where subsoils do not drain adequately, installation of subsurface drainage systems may be recommended.

   Rainfall will satisfy a portion of the leaching requirement, depending on the rate, volume, and distribution through the season. The frequency with which leaching applications should be made depends on the several variables, and is triggered by approaching soil salinity thresholds defined above.

5. Apply gypsum prior to leaching when indicated by soil analysis. Gypsum ($CaSO_4$) is a soil amendment that, when combined with leaching, helps lower soil sodium concentrations. Gypsum application should be considered when soil analyses reveal one or more of the following conditions: SAR exceeds 6.0, SAR increases 2 units or more (e.g. 2.3 to 4.3), and/or sodium concentration exceeds 5 meq/l (115 mg/l). The amount of gypsum needed and the frequency of application depend on site-specific soil and water characteristics, and are determined by laboratory analysis.

6. When using recycled water, irrigation frequency should be adjusted as needed to maintain moist soil. Drought stress occurs at higher soil moisture as water quality declines because the salts increase the osmotic pressure. As the soil dries, the salts in the soil solution become more concentrated, and plant damage is more likely to occur. Irrigation systems with non-uniform application patterns may need to be upgraded to avoid dry areas.

7. For plants that are not adapted to prolonged drought, avoid minimal irrigation strategies that result in dry soils and plant water stress. It is important to maintain a relatively moist soil to dilute salts in the soil.

8. Perform an irrigation system audit to quantify application rates and variation in application pattern. This information is needed to schedule irrigation and leaching programs and to identify potential problem areas that need modification.

9. Modify irrigation systems to avoid wetting plant foliage during operation. Adjust spray patterns on sprinkler systems to lower the trajectory.

10. Consider installing soil moisture monitoring equipment to measure the soil moisture at various depths within and below plant root zones. This information would be helpful in evaluating effectiveness of irrigation schedules and leaching treatments.

Evaluation of Use of Recycled Water for Landscape Irrigation
Palo Alto Recycled Water Project, Phase 3
Palo Alto, CA

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Evaluation of Use of Recycled Water for Landscape Irrigation
Palo Alto Recycled Water Project, Phase 3

PREPARED FOR:
RMC Water and Environment
San Francisco, CA

Introduction

RMC Water and Environment is preparing an Environmental Impact Report for the Palo Alto Recycled Water Project, Phase 3. The project site is located in the Stanford Research Park area. HortScience, Inc. was asked to contribute to that effort by performing site evaluations and assessing the potential effects of irrigation with the project recycled water on the existing landscapes.

Irrigating landscapes with recycled water is an important component of Palo Alto's efforts to conserve water resources. By applying recycled water to landscapes, potable water is conserved for human consumption. Recycled water contains plant nutrient elements such as nitrogen. Improvement in turf growth and appearance has been noted when recycled water is applied due to the nitrogen content.

Conversion of landscape irrigation from potable to recycled water, however, may require some adjustments to the plant palette and landscape management. Recycled water contains salts that, over time, can damage sensitive plants and degrade soil quality. The degree to which plants and soils are affected depends in part on the quality of the recycled water, primarily the concentrations of salts.

This report includes:

- descriptions of the soils and plants present at the four sites;
- evaluation of the quality of the current RWQCP recycled water with regard to landscape irrigation;
- assessment of the salt sensitivity of each of the landscape plant species inventoried;
- discussion of the opportunities and constraints the plant palette, current plant condition, and/or soil characteristics may have on successful use of recycled water for irrigation; and
- descriptions of options for water treatment, soil modification, and/or landscape management activities that could minimize potential negative effects.

Evaluating response of landscapes to recycled water

The response of an existing landscape to irrigation with recycled water depends on the degree to which soil will become affected and the tolerance of plant materials to salts and specific ions. Evaluation of sites for irrigation with recycled water must consider water, plant, and site factors as well as irrigation management. There are several factors to consider when evaluating site suitability for irrigation with recycled water.

1. ***Water quality –*** The poorer quality the water (i.e., the higher the salt concentration), the more likely plants will be injured.

2. ***Soil characteristics –*** As a rooting environment, the soil holds the water and nutrients for root uptake. Some constituents in recycled water can have negative effects on the soil over time. The soil characteristics of key importance include:

    a. **Chemical characteristics –** Soils with low concentrations of salts or low pH can accumulate more salts from the water before plant tolerance thresholds are exceeded.

    b. **Texture of the soil** - Clay (fine-textured) soils are more quickly degraded by excess sodium than sandy (coarse-textured) soils.

    c. **Soil profile** – The vertical gradation or layering with soil depth affects water percolation, salt accumulation and plant rooting patterns.

    d. **Soil drainage -** Soils with poor drainage characteristics accumulate salts and cannot be easily leached. The poorer the drainage, the better quality water required.

    e. **Soil structure –** Soil structure can be affected by salts and particularly in clay soils can be changed in ways that affect permeability and drainage.

3. ***Salt-sensitivity of plants in the landscape.*** Plants vary widely in their tolerance to salts. Salt -and boron -sensitive plants have less tolerance to use of some recycled waters than do more salt tolerant species.

4. ***Irrigation method and frequency.*** Plants are more sensitive to sodium and chloride toxicity when water is applied to the foliage as opposed to the soil. Therefore, sensitive plantings irrigated by sprinklers require water with lower concentrations of sodium and chloride. Drip irrigation emitters can become clogged by carbonate precipitates and suspended solids if present in the water.

    Drought stress occurs at higher soil moisture as water quality declines because salts increase the osmotic pressure. When using water having higher salt concentrations, irrigation frequency should be adjusted to maintain a moist soil. As the soil dries, the salts in the soil solution become more concentrated and plant damage is more likely to occur.

Our analysis of the Stanford Research park landscapes and recycled water investigated the above factors.

Investigation approach and methods of study

Water quality

The Palo Alto Regional Water Quality Control Plant (RWQCP) produces the recycled water. Analysis of recycled water was provided by the City of Palo Alto:

These values were compared to landscape water quality guidelines and thresholds (see Appendix 1 for further information about evaluating water quality).

Site Evaluation

To evaluate the potential response of landscapes to the RWQCP recycled water, we devised a site evaluation strategy that assessed soil conditions and plant species components that could affect landscape response. Based on a brief site survey and using USDA Soil Conservation Service soil maps we selected seven properties located on the primary mapped soil units within the area and having a range in landscape types (Fig. 1, Table 1).

Soils

At each property we investigated the soil characteristics at one to three areas for a total of 13 sites. At each site we hand-excavated the soil using a 3 ¼ inch auger. The soil profile was described in terms of texture, layers, moisture, and presence of roots. Soil samples were collected at various depths within the profile and sent to Perry Laboratory (Watsonville, CA) for chemical analysis.

Plant palette and plant salt tolerance

Plant species vary in their tolerance to salts. At each property we identified the plant taxa present and described the general condition of the plants (good, fair, poor). In addition we estimated the relative frequency of occurrence of the taxon in the landscape (common throughout landscape, occasionally present within the landscape, one to a few plants present).

For each plant taxon we estimated its salt tolerance (high, moderate, low) based on information available in the literature and our experience with the species in landscapes irrigated with recycled and low quality waters.

Photo 1: Sites were selected to represent the range in landscape conditions within the Palo Alto Phase 3 project area. For example, Mitchell Park (left) is on a lowland basin and has a mature landscape that requires regular irrigation. The Theranos property (right), located on a terrace, has been planted with drought tolerant plants requiring infrequent irrigation. These differences affect the landscape response to irrigation with recycled water.

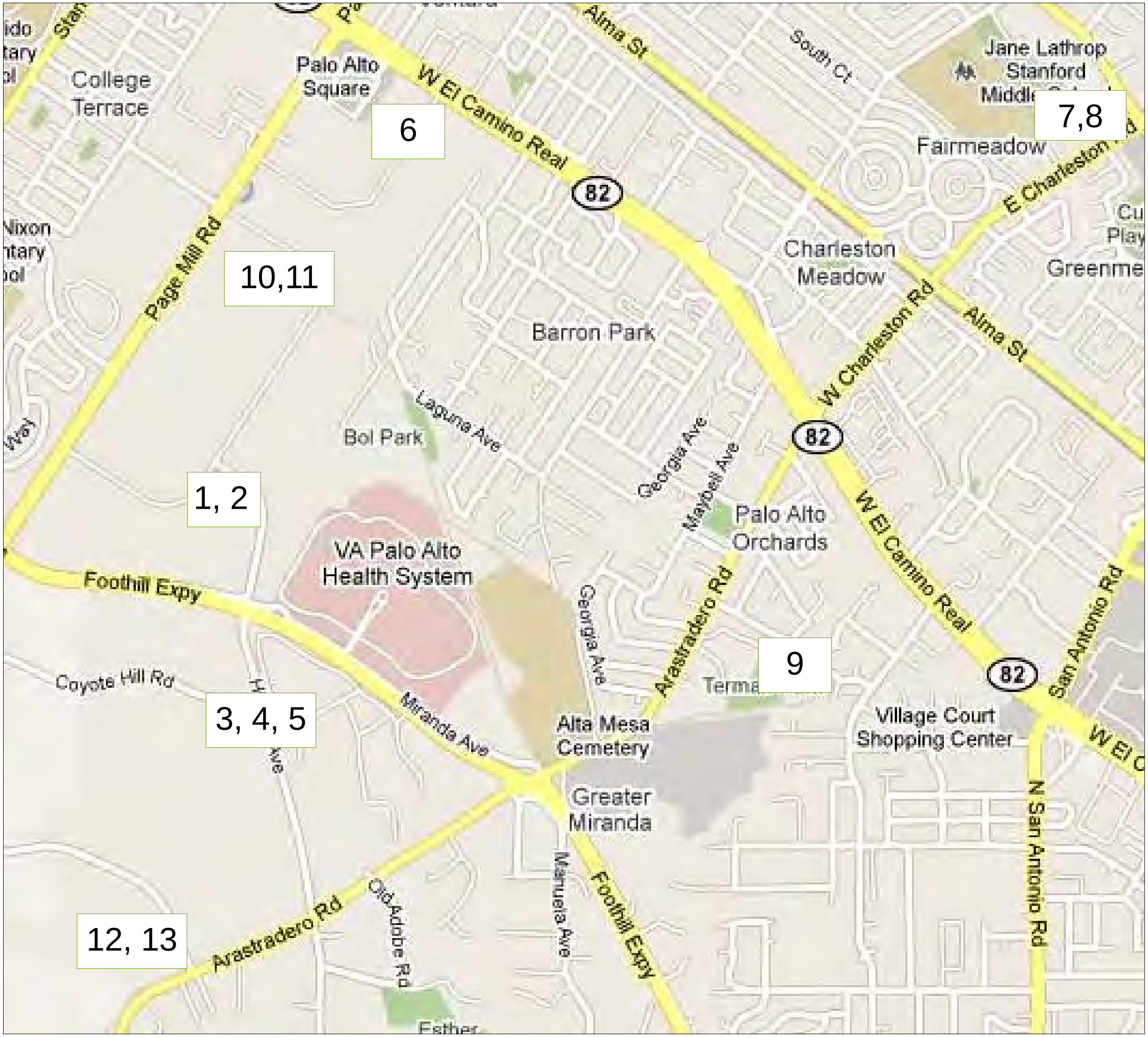


Fig. 1
Study Site Locations

Palo Alto Recycled Water Project

Phase 3

Site	Property
1, 2	Theranos 3200 Hillview
3, 4, 5	VMWare 3401 Hillview
6	Clocktower 600-660 Hansen Wy.
7, 8	Mitchell Park 600 East Meadow Dr.
9	Terman Park 655 Arastradero Rd.
10, 11	Hewlett Packard 3000 Hanover St.
12, 13	Tesla Motors 3500 Deer Creek Rd.

Table 1: Characteristics of representative properties. City of Palo Alto. Refer to Fig. 1 for locations.

Site	Property	Soil series	Site description	Landscape plants
1, 2	Theranos 3200 Hillview	San Ysidro loam, Zamora clay loam	Appeared to be near natural grade (native oak nearby).	Recently renovated to drought tolerant landscape; some mature pines retained; native oak nearby.
3, 4, 5	VM Ware 3401 Hillview	Gaviota loam, Los Trancos stony clay	Native grade maintained along the perimeter; extensive grade changes (cuts) in the interior.	Recently renovated; mix of water demand from low to high; mature redwoods and pines retained; native oaks along Hillview.
6	Clocktower 600-660 Hillview	Dublin clay	Near natural grade with some shallow fill soils.	Mature landscape, predominately moderate to high water requiring plants including redwoods
7, 8	Mitchell Park 3800 Middlefield Rd.	Sunnyvale clay, Clear Lake clay	Near natural grade.	Mature landscape; wide range of species with varying water requirements and salt tolerance; mature redwoods.
9	Terman Park 695 Arastradero Rd.	Pleasanton gravelly loam	Near natural grade.	Mature landscape; predominately turf. Plants at adjacent school included in inventory.
10, 11	Hewlett Packard 300 Hanover St.	Ohmer clay loam, Pleasanton gravelly loam, Milpitas	Southeast portion appears to be natural grade (native oaks retained); cuts and fills to the north.	Mature landscape; wide range of species with varying water requirements and salt tolerance; mature redwoods; native oaks.
12, 13	Tesla Motors 3500 Deer Creek Rd.	Ohmer clay loam, Gaviota clay	Natural grade along the perimeter and small section in the interior (native oaks retained). Deep cuts throughout.	Recently renovated site with new landscaping installed around buildings; wide range of species with varying water requirements and salt tolerance; mature perimeter landscapes retained; native oaks

Results and discussion

1. Water quality

For recycled water, the quality depends on the components of the water prior to use (potable water), what components were added during use, and what type of treatments were used to remove components to produce the recycled water. For any given potable water, however, the concentration of salts will be lower than in the water after recycling. When evaluating potential effects on the landscape, the water constituents of primary concern are total salts, concentration of specific ions, sodium adsorption ratio, bicarbonate, and nutrient concentration.

Total salts

Salinity is the most important measure of water quality for landscape plants. It is expressed as total dissolved solids (TDS) and electrical conductivity (EC_W). When water is applied to soils, some of the salts in the water (notably Na^+, Cl^- and B^+) remain in the soil. As these salts accumulate in the soil, plant damage may occur. Salt toxicity is first expressed as stunting of growth and yellowing of foliage. As more salts are taken up by the plant, burning of the edge of the leaves and defoliation may develop (photo 1). In severe cases, plants are killed. The degree of the problem depends on the sensitivity of the plant to salts and the concentration of the accumulated salts in the soil.

Photo 1: London plane leaf damaged by salts in the irrigation water (average Ec_w=1.5 mmhos/cm).

Specific ion concentration

While a measurement of salinity will express the total salt content, it may not adequately identify potential damage from accumulation of specific ions. High concentrations of chloride (Cl^-), sodium (Na^+) and boron (B^+) in recycled water can injure sensitive plants (photo 2). Boron in particular must be evaluated independently of other salts. It is toxic in such low concentrations (<1 ppm), that its presence will not be reflected in the total salinity measurement.

Photo 2: Mulberry leaf damaged by boron in the irrigation water (average B=0.8 mg/l).

Sodium and chloride concentrations are particularly important if irrigation water will be supplied by sprinkler. Plants will absorb both ions through their foliage. Salt damage through foliar absorption will occur at much lower concentrations than through soil absorption, particularly under high evapotranspiration conditions. For this reason interpretation of water quality is different for foliar applied (e. g. spray irrigation that wets plant foliage) than for soil applied (e.g. bubbler or drip irrigation). Therefore water quality may be identified as poor for foliar application and fair for soil application.

The toxicity symptoms of the specific ions are often difficult to distinguish from each other. Leaf chlorosis and marginal burning are typical. Necrosis associated with boron is often black in color and may appear as small spots near the leaf margin.

As with salinity, plant tolerance to individual ions is highly species-specific. Some plants, like Indian hawthorn *(Raphiolepis indica*), can tolerate boron in excess of 7 ppm. Others like coast redwood *(Sequoia sempervirens*) are injured at a fraction of that. Furthermore, a plant may be relatively tolerant of boron, but highly sensitive to chloride.

Little information is available to help develop lists of sensitivity of plants to specific ions. The landscape manager must rely primarily on experience and observation.

Sodium adsorption ratio

In addition to affecting plants directly, sodium can have direct effects on soil structure. If present in high concentrations, sodium may cause dispersion of soil aggregates. This decreases soil permeability to water and air, which may cause plant decline and death. Soils high in clay are particularly susceptible to breakdown of aggregates by sodium.

Sodium hazard to soils is usually assessed by determining the sodium adsorption ratio (SAR), a value calculated from sodium, calcium and magnesium concentrations. However, the permeability problems that can be associated with a high SAR can be partially offset by salts in the water. A more accurate measure of potential problems in irrigation water is the adjusted sodium adsorption ratio (adj R_{Na}) calculated from the salinity, bicarbonate, calcium, sodium and magnesium concentrations of the water.

Bicarbonate

Bicarbonate (HCO_3^-) affects plants through its influence on pH and interaction with sodium. High bicarbonate concentrations can cause interveinal chlorosis (tissue between leaf veins is yellow, Photo 3).

Photo 3: Interveinal chlorosis on sweetgum.

Application of water high in bicarbonate, calcium, and/or magnesium can result in a white precipitate forming on surfaces wetted by sprinkler irrigation. Irrigation hardware is also susceptible to damage from bicarbonates. The precipitates can clog drip emitters, and increase wear of valves.

When bicarbonate combines with calcium or magnesium in soils, calcium carbonate and magnesium carbonate form precipitates. Consequently the SAR of the soil increases, and permeability to water may become a problem. The bicarbonate hazard to soils can be evaluated by calculating the residual sodium carbonate (RSC). The RSC is the sum of the carbonate and bicarbonate ions minus the sum of calcium and magnesium ions. Water with an RSC>2.5 meq/l can develop permeability problems.

Nutrients
One of the advantages of using recycled water for landscape irrigation is that it contains plant nutrients and reduces the need for application of fertilizer. Nitrogen, phosphorus, and sulfur are the elements of greatest benefit. Their concentrations are considered when evaluating recycled water to determine fertilization needs. Recycled water usually contains most of the micronutrients needed by plants.

A negative aspect of enhanced fertility involves storage of recycled water. Ponded nutrient-laden water develops algae and other aquatic weed problems more rapidly than potable water.

RWCQP water quality

In evaluating the likely landscape responses to the recycled water we considered the maximum and mean concentrations of total salts, boron, sodium chloride, bicarbonate, and the calculated value for adjusted sodium adsorption ratio. A summary of the data is provided in Table 1; refer to Appendix 2 for the complete data set.

We compared summary data to published guidelines and our professional experience with landscapes irrigated with recycled water. For the constituents most important to managing landscape irrigation, the water quality ranges from good to poor for sprinkler irrigation and good to fair for drip irrigation (Table 2). A summary is provided below:

Boron, nitrogen, pH	No restrictions to plant performance are anticipated. The nitrate component will enhance plant growth and reduce need for applied fertilizers.
Total salts, SAR	Gradual increases in soil salinity and soil sodium adsorption ratio (SAR) are expected. Treatments to mitigate these effects are discussed later in this report. Carbonates, when combined with calcium, are likely to leave white deposits on foliage under sprinkler irrigation. This is primarily an aesthetic issue, not one of plant health.
Sodium, chloride	Damage likely to occur in sensitive plant species. Treatments to mitigate these effects are discussed later in this report. Foliar damage may develop in moderately tolerant species where salts accumulate in the soil over years of application, or where native soil salinity is high.

Bicarbonate and carbonate data were not available, so we were not able to calculate adjusted sodium adsorption ratio or residual sodium carbonate.

Table 2: RWQCP reclaimed water analysis for July 2007-June 2008[1]

Parameter	Minimum	Maximum	Mean	Salinity Hazard[2]
TDS (mg/l)	870	1000	963	slight
EC_w (µmho/cm)	1518	1760	1656	moderate
Boron (B, mg/l)	0.31	Al	0.35	none
Chloride (Cl, mg/l)	308	384	339	moderate
Sodium (Na, mg/l)	170	240	211	moderate
Sodium adsorption ratio	5.3	5.9	5.0	none
Alkalinity	85	196	114	none
Nitrate (NO_3, mg/l)	19	26	23	none
pH	6.6	7.2	7.0	none

[1]Data provided by City of Palo Alto, Nov. 2008 – Aug. 2010. See Appendix 2 for all data.
[2]Refer to *Evaluating Water Quality*, Appendix 1.

2. *Soil characteristics*

To evaluate the potential response of the landscape to the RWQCP recycled water, we examined the soil in thirteen locations at seven properties (Table 3). Soil investigations were performed and described by David Kelley, KAES, Inc. Twenty-six soil samples were collected and sent to Perry Laboratory (Watsonville, CA) for chemical analysis.

The results of the site investigation and laboratory analyses of samples are presented in the *Site Evaluation: Soil Assessment* (Appendix3). Chemical analyses of soil samples are provided in the Appendix 4, with key components provided on the Soil Assessment exhibits.

Table 3: Locations of soil investigations.

Refer to Appendix 3 for maps of soil sample locations.

Site No.	Property	Location	Excavation depth	No. soil samples
1	Theranos	Southwest corner, near Arten Rd.	36”	3
2	Theranos	East parking lot island	24”	2
3	VMWare	On mound along Hillview, east side of property	24”	2
4	VMWare	Retained landscape area in northwest parking lot.	18”	1
5	VMWare	Parking lot island west of bld. #3407 .	24”	2
6	Clocktower	Landscape area between building and north parking lot.	32”	3
7	Mitchell Park	Northwest end of park near Meadow Dr.	60”	3
8	Mitchell Park	East side of library	60”	1
9	Terman Park	Northwest corner	60”	2
10	Hewlett Packard	Southeast corner west of volleyball court	42”	2
11	Hewlett Packard	South of buildings between parking lots by basketball court	20”	1
12	Tesla Motors	East side between Deer Creek Rd. and building	24”	2
13	Tesla Motors	Southwest corner between parking lot and open space	22”	2

Soil Landscape and Geomorphic Setting

The land area of the project ranges across the City of Palo Alto in a meandering transect from hills (uplands) on the west to lowland basins just upslope from the western edge of San Francisco Bay on the east. Sample sites were west of Highway 101.

The uplands are landscapes of hillslopes, older and more recent alluvial fans, and terraces, dissected by small drainages (intermittent creeks). The lowlands comprise basins and discrete floodplains of generally flat or low gradient surface configurations. San Francisquito, Los Trancos, and San Francisco Creeks generally border the project area on the north, northwest, and south sides respectively, and are the primary source of sedimentary deposits that became the parent materials of the soils of the basins, terraces, and floodplains.

Most of the lands were farmed or grazed in the past and are now devoted to buildings and roadways and associated green spaces and horticultural plantings. Some examples of remnant native plants (valley and coast live oaks) mark original grades in some places. In general, original landforms have been rendered unrecognizable by development grading, though most features can be detected with study. Landforms are of some importance in interpreting the ability of these soils to accept irrigation waters, though surface soils have undergone substantial disturbance and water tables in the area have changed with development.

Mapped Soils

Soils of the study area were mapped by the US Department of Agriculture's Bureau of Soils prior to 1914 (Lapham, 1917), and jointly by the Soil Conservation Service (now the Natural Resources Conservation Service) and the University of California Agricultural Experiment Station in the 1950's's (Gardner, *et al.*, 1958). Soil series' names were changed with the newer mapping, and some of the old series were split into more precise mapping units. The newer names will be used in this report, though newer statewide correlations have occurred since the 1950's and these names may not be entirely up to date.

The early map shows that the study area was partially developed in the early part of the last century, but that most of the land was in crops or grazed. Maps from the 1950's show a great deal more development, generally across the study area (though the upland portions were probably developed somewhat later). The 1914 maps show the positions of sloughs and creek channels extending into the tidal flats to the east of the study area; some of these can still be identified on modern maps and on the ground. Modern soil mapping efforts (Gardner, *et al.*, 1958) undertaken in the 1950's served to update the 1914 map, though they do not provide aerial photo base maps as the modern surveys do. Correlation of water features and roadways between the two mapping efforts is good.

The soils of the project area, as mapped in the modern survey, include soils of hillslopes, alluvial fans, terraces, basins, and floodplains. Historically these soils were put to different uses depending on their capabilities and accessibility. Productive flat soilscapes of the basins and floodplains were generally fine-textured and sometimes salt-affected, and generally planted to grain or truck crops. Soils in upland positions—

notably terrace and alluvial fan soils—were more frequently planted to tree crops. These capabilities are indications of the abilities of these soils to accept recycled water as an irrigation source. Hillslope soils were more often devoted to grazing with little irrigation. Characteristics of the mapped soils across the project site are discussed below, by soil series. These descriptions apply to the mapped soils; more intensive descriptions of the soils encountered in this study are provided in later sections of this report.

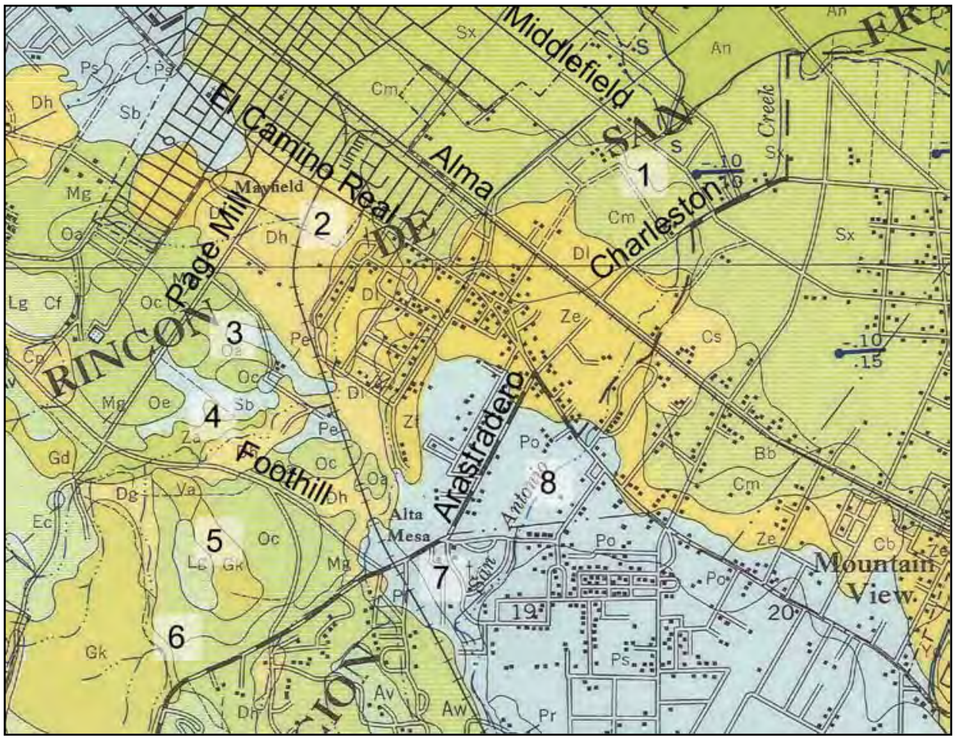


Fig. 2: Detail of 1914 USDA SCS soil map for the project area. Approximate locations of sites investigated are identified by number.

Clear Lake Clay (Cm)

These are dark gray clays of basins in low-lying positions in the landscape. The dark, non-calcareous surface soils overlie a lighter colored calcareous subsoil. The upper subsoil is compact and is a moderately strong barrier to water and root penetration. Lower subsoils are calcareous but more permeable, and may be slightly saline. This soil is present at Mitchell Park.

Dublin Clay (Dh)

Soils of the Dublin series are found on alluvial fans and are generally deep and are dark, fine-textured, and moderately permeable. The soils drain slowly, but tree roots can penetrate to 6 feet or more. These soils often overlie other fine-textured soils that may be less permeable. This soil is present at the Clocktower property.

Gaviota Loam (Gk)
The soils of the Gaviota series are hillslope soils of moderate depth and fairly high permeability. They are steep in places, and are coarse textured and overlie a sandstone parent material. They are generally associated with some gravelly horizons at moderate depth. Tree root penetration is generally good where the soils are deep above bedrock. This soil is present at VMWare and Tesla Motors

Los Trancos Stony Clay (Lg)
These are hillslope soils of volcanic parent materials. They are generally shallow above bedrock, steep, and slowly permeable. The fine-textured parent materials are weathered and nutrient poor. This soil is present at the VMWare property.

Ohmer Clay Loam (Oc)
These soils are older terrace soils with very slowly permeable subsoils. The subsoils may be gravelly clays within 15 inches of the surface and in general these soils do not accept irrigation waters well. Tree root penetration is poor. Fertility is low. Where excavation for development has exposed clayey subsoils as a planting surface, plant response is poor. This soil is present at Hewlett Packard and Tesla Motors.

Pleasanton Gravelly Loam (Po)
The Pleasanton soils are alluvial fan and floodplain soils that occur extensively in the study area. They are often clayey and gravelly, with good root penetration capabilities and moderate to good water infiltration capabilities. In most cases, these soils support strong tree growth and are suitable for irrigation water application because of their permeability. This soil is present at Hewlett Packard and Terman Park.

San Ysidro Loam (Sb)
The San Ysidro soils are similar to the Pleasanton soils—they occur on alluvial fans and are relatively deep--but are characterized by a dense near-surface clay horizon that impedes root penetration and water infiltration. These soils tend to saturate and stay wet during the rainy season because of the compact clay subsoils, and are not well suited to tree growth. This soil is present at the Theranos property.

Sunnyvale Clay (Sx)
Sunnyvale clays occur in basin positions and are very dark (black) clays of low permeability and poor root penetration capability. They lie adjacent to Clear Lake clays in the project area, but have a deeper and more uniform profile and more restrictive subsoils. They may have a high water table in some areas, and may be slightly saline. This soils is present at Mitchell Park

Zamora Clay Loam (Za)
The soils of the Zamora series occupy younger alluvial fans and are generally well drained and permeable, with good root penetration and water infiltration characteristics. They are somewhat coarser textured than some of the clay soils in

the project study area, and may be better suited to accept irrigation waters. Their subsoils are generally permeable. This soil is present at the Theranos property.

In the course this study, an attempt was made to sample from all series mapped on the various project locations, in part to determine the fidelity of the existing soil characteristics to those of the mapped units of the soil survey reports. Because the soilscapes have been greatly disturbed by development, it was not always possible to assess that fidelity. In the main, the soils exposed in auger pits in this study correlated well with mapped series of the 1958 soil survey.

Soil Physical Characteristics

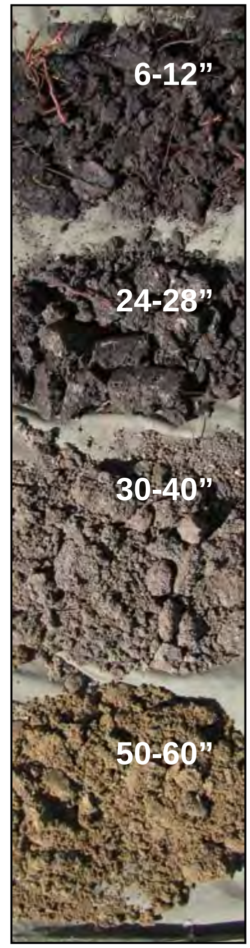
To examine soil profiles and acquire samples for analysis, pits were hand dug with an auger and spade. Profiles were described by examining auger tailings from the soil profiles and estimating profile depths, horizon changes, qualities of soil, moisture content, rooting density, and other characteristics.

Photo 5: Soils were excavated by hand using a soil auger.

Excavated pits ranged in depth from 18” to 60”. Excavation depths at sites 2-5, 12 and 13 were limited by presence of gravel and stones.

Examination of backhoe trenches would allow more complete inspection, evaluation, and sampling. Because the sites were developed, however, we were limited to hand-dug auger pits. Where excavation will occur in the future, for instance to install below-ground infrastructure, it would be informative to conduct additional soil inspections to buttress and supplement examinations made with hand augers and provide more detailed descriptions of the soils. The examination of *in situ* profiles allows an assessment of horizon characteristics and associated conditions and features (soil moisture content, root distribution, textural variability, clast size and distribution, and depth to near-surface water tables). This approach would allow better characterization of the soils and better interpretations of their suitability for the application of irrigation waters.

Photo 6: Soil excavated at site 7 were clay in texture but varied in structure color, moisture, chemical characteristics and presence of roots with depth.



As expected from the survey report descriptions, soils of the project area are of variable texture (particle size) and structure (particle aggregation), of somewhat mixed lithologies (parent materials), occasionally stratified and frequently compacted, and not possible to characterize uniformly because they are variable across the landscape. The soils also were variable, most notably, across the various landforms they occupy.

Soils were generally fine in texture: silt loam, silty clay loam, clay loam, and clay. As mentioned previously, gravels were common. Imported fill soils were present atop old landscape surfaces at sites 1, 2, 5, 6, and 9. In some cases roots were present to the depth of excavation – over 60” at sites 7 and 9. At other sites roots were confined to the top 18” (sites 3 and 5).

Wide variations in soil moisture were noted. Soils were generally moist throughout the profile at sites 1 and 10, and dry at sites 3, 4, 11, and 12. At sites 2, 6, 7, 8, and 13, the surface soils were dry and slightly moist at depth. The opposite condition – moist surface soils and dry at depth – was found at sites 5 and 9. These variations are primarily due to presence or absence of irrigation, and the amount of water applied to the landscape. Sites 3, 11, 12, and 13 did not appear to be irrigated.

The variability of the profiles, particularly with regard to texture, structure, and stratification, can present problems for plant growth, root penetration, and water and gas exchange. For some of the soils examined, the features mentioned—high clay content, compacted horizons, and varying moisture content by horizon—complicate prescriptive irrigation and nutrient delivery systems. In a system where leaching is necessary and water throughflow is desirable (as in this case, where salt content of the irrigation waters and native soils is problematic), the recognition of these complications is a prerequisite for irrigation planning and management.

Soil chemical characteristics
The chemical composition of the soils with regard to salts (Ec_e, Cl, Na, B, SAR) was similar among the 26 soil samples analysed (Table 4). In all samples the salt concentrations were low and within the range of tolerance of salt sensitive plants.

Soil pH was more variable, ranging from 5.5 (acidic) to 8.0 (alkaline). Average pH was 7.0 (neutral), which is optimum for most landscape plants.

Table 4: Summary of soil analyses for samples collected at seven study sites. City of Palo Alto. (see Appendix 4 for all soil analyses)

Property	Sample No.	Depth	pH	Salinity (Ec$_e$ dS/m)	Sodium (meq/l)	Chloride (meq/l)	Boron (ppm)	SAR
Theranos	1A	6-12"	6.7	0.6	1.0	0.6	0.2	0.7
	1B	18-24"	6.3	0.3	1.5	1.4	0.3	1.5
	1C	30-36"	6.8	0.3	1.1	0.8	0.2	1.2
	2A	6-12"	7.1	0.3	1.2	0.6	0.2	1.2
	2B	14-20"	7.4	0.2	1.1	0.6	0.1	1.9
VM Ware	3A	6-12"	5.8	0.2	1.0	0.6	0.4	1.3
	3B	14-20"	6.1	0.2	1.0	0.8	0.3	1.7
	4A	6-12"	5.5	0.4	1.8	1.8	0.4	1.6
	5A	6-12"	8.0	0.4	1.8	0.8	0.3	1.9
	5B	12-24"	7.6	0.6	2.5	1.0	0.1	2.1
Clocktower	6A	6-12"	7.4	0.5	1.7	0.8	0.1	1.4
	6B	14-18"	7.5	0.7	2.2	1.6	0.2	1.5
	6C	18-26"	7.5	0.7	2.3	1.4	0.2	1.4
Mitchell Park	7A	6-12"	6.8	0.4	2.0	1.6	0.4	2.2
	7B	28-34"	7.9	0.5	1.7	1.0	0.5	1.3
	7C	52-58"	8.0	0.9	1.7	1.8	0.3	0.9
	8A	6-20"	7.8	0.3	1.3	0.8	0.3	1.2
Terman Park	9A	6-12"	7.0	0.3	1.2	0.6	0.2	1.3
	9B	20-40"	7.0	0.3	1.3	0.4	0.2	1.5
Hewlett Packard	10A	4-8"	7.1	0.5	1.1	1.2	0.4	0.8
	10B	36-42"	7.8	0.03	1.0	1.0	0.3	1.0
	11A	4-8"	6.4	0.8	2.4	4.4	0.4	1.6
Tesla Motors	12A	4-8"	6.6	0.4	1.2	1.6	0.4	1.0
	12B	20-24"	6.8	0.2	1.1	1.0	0.4	1.5
	13A	6-12"	7.9	0.4	1.5	1.0	0.3	1.3
	13B	16-22"	6.9	0.5	1.0	1.2	0.2	0.6

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3. Salt sensitivity of landscape plants

Because plants vary widely in their tolerance to salts it is necessary to know what species are present to evaluate the potential response of the landscapes to recycled water. We identified each species present in the landscape, evaluated its overall condition (good, fair, poor), and estimated the relative frequency of occurrence of the species in the landscape (common throughout landscape, occasionally present within the landscape, one to a few plants present). Finally, for each plant species we estimated its salt tolerance (high, moderate, low) based on information available in the literature and our experience with the species in landscapes irrigated with recycled and low quality waters.

Plant inventories for each of the seven properties are provided in Appendix 5. In total, 227 taxa were identified. Overall the landscapes appeared attractive and healthy. Except for new plantings at Theranos, VMWare, and Tesla Motors, the plants were mature and well established. Trees at sites 4 (VMWare), 11 (Hewlett Packard), and 12 (Tesla Motors) appeared to be under water stress.

Rankings for salt tolerance are provided in Appendix 5 and summarized in Table 5.

- Plants in the 'low' category (47 taxa, 21%) are likely to be affected when soil salinity (Ec_e) exceeds 2 dS/m.
- Those in the 'moderate' category (89 taxa, 39%) are likely show symptoms of salt excess when soil salinity exceeds 4 dS/m.
- Plants in the 'high' category (80 taxa 35%) are generally tolerant of soil salinity below 6 dS/m.
- For 11 taxa (5%) there is no information in the literature about salt tolerance, and we have no experience with the species in landscapes irrigated with recycled water.

Photo 7: The landscapes studied were comprised of a mix of plant taxa having a range of salt tolerance. Examples are (left) Canary Island pine (*Pinus canariensis*) – high; (center) maidenhair tree (*Ginkgo biloba)* – moderate; (right) coast redwood (*Sequoia sempervirens*)- low

To identify the primary taxa in the plant palettes we described the frequency of occurrence in the landscape. Principal plant taxa were identified based on frequency of occurrence and number of sites in which they occurred. Principal plants were taxa that were classified as 'common' in one or more properties, and 'several' in two or more properties. Annual plants were excluded. Of the 227 taxa, 98 (43%) were principal plants. Of the principal plants, 42% had high, 35% moderate, 17% low, and 5%, unknown salt tolerance (Table 6).

Table 5: Salt tolerance rankings for landscape plants at seven properties. City of Palo Alto. (Refer to Appendix 5 for complete lists)

Site	No. taxa	Salt tolerance rankings for taxa			
		High	Moderate	Low	Unknown
Theranos	50	19	23	5	3
VM Ware	73	30	25	15	3
Clocktower	51	12	20	18	1
Mitchell Park	74	26	33	14	1
Terman Park	36	13	13	9	1
Hewlett Packard	84	33	29	17	5
Tesla Motors	38	17	16	5	0
Total, all taxa*	227	80 (35%)	89 (39%)	47 (21%)	11 (5%)
Principal plants+	99	42 (42%)	35 (36%)	17 (17%)	5 (5%)

*Duplicates excluded

+Taxa commonly occurring in one or more locations and several occurring in two or more locations; annual plants excluded.

Table 6: Estimated salt tolerance of principal plants at seven properties. City of Palo Alto. (See Appendix 5 for complete inventories)

Key Plants with High Salt Tolerance			
Scientific name	**Common name**	**Scientific name**	**Common name**
Arctostaphylos cultivars	Manzanita	*Lavatera maritima*	Tree mallow
Baccharis pilularis	Dwarf coyote brush	*Maytenus boaria*	Mayten
Calamagrostis x acutiflora 'Karl Foerster'	Reed grass	*Miscanthus sinensis* 'Gracillimus'	Maiden grass
Caryopteris x clandonensis	Blue mist	*Muhlenbergia rigens*	Deer grass
Ceanothus cultivars	Wild lilac	*Myoporum parvifolium* 'Prostratum'	Myoporum
Cotoneaster lacteus	Parney's cotoneaster	*Nerium oleander*	Oleander
Dietes iridiodes	Fortnight lily	*Olea europaea*	Olive
Eucalyptus globulus	Blue gum	*Pennisetum orientale*	Oriental fountain grass
Eucalyptus polyanthemos	Silver dollar gum	*Phormium hybrids*	Flax
Eucalyptus viminalis	Manna gum	*Pinus canariensis*	Canary island pine
Euonymus japonica	Evergreen euonymus	*Pinus pinea*	Italian stone pine
Galvezia speciosa	Is. bush snapdragon	*Pinus radiata*	Monterey pine
Hedera canariensis	Algerian ivy	*Pittosporum tobira* cvs.	Tobira
Hedera helix	English ivy	*Pyracantha coccinea*	Firethorn
Hemerocallis hybrids	Daylily	*Pyrus calleryana*	Callery pear
Heteromeles arbutifolia	Toyon	*Quercus agrifolia*	Coast live oak
Iris douglasiana	Pacific coast iris	*Quercus rubra*	Red oak
Juniperus chinensis cvs.	Juniper	*Rhaphiolepis indica*	Indian hawthorn
Lampranthus spectablis	Ice plant	*Robinia x ambigua* 'Purple Robe'	Locust
Lantana montevidensis	Lantana	*Rosmarinus officinalis*	Rosemary
Lavandula angustifolia	English lavender		

Table 6, continued: Estimated salt tolerance of principal plants at seven properties. City of Palo Alto. (See Appendix 5 for complete inventories)

Principal Plants with Moderate Salt Tolerance			
Scientific name	**Common name**	**Scientific name**	**Common name**
Equiseteum hyenale	Horsetail	*Penstemon cultivars*	Penstemon
Escallonia rubra	Escallonia	*Photinia x fraseri*	Photinia
Festuca calfornica	California fescue	*Pistacia chinensis*	Chinese pistache
Festuca rubra	Red fescue	*Pittosporum undulatum*	Victorian box
Fraxinus angustifolia 'Raywood'	Raywood ash	*Platanus x acerfolia*	London plane
Fraxinus uhdei	Evergreen ash	*Prunus cerasifera* 'Atropurpurea'	Purple-leaf plum
Ginkgo biloba	Maidenhair tree	*Prunus laurcerasus* cvs	English laurel
Hypericum calycinum	St. Johnswort	*Quercus ilex*	Holly oak
Ligustrum japonicum	Privet	*Quercus lobata*	Valley oak
Ligustrum lucidum	Glossy privet	*Rosa cultivars*	Groundcover rose
Liriope muscari cultivars	Big blue lily turf	*Teucrium fruticans*	Bush germander
Lonicera japonica 'Halliana'	Hall's honeysuckle	*Trachelospermum jasminoides*	Star jasmine
Melaleuca quinquenervia	Cajeput tree	*Ulmus parvifolia*	Chinese evergreen elm
Nasella tenuissima	Mexican feather grass	*Xylosma congestum*	Xylosma

Principal Plants with Low Salt Tolerance			
Scientific name	**Common name**	**Scientific name**	**Common name**
Agapanthus africanus cvs	Lily-of-the-Nile	*Magnolia grandiflora*	Southern magnolia
Berberis thunbergii cvs	Japanese barberry	*Michelia doltsopa*	Michelia
Betula pendula	European white birch	*Ophiopogon japonicus*	Mondo grass
Citrus x limon	Lemon	*Parthenocissus tricuspidata*	Boston ivy
Fragaria chiloensis	Ornamental strawberry	*Polystichum munitum*	Western sword fern
Lagerstroemia indica	Crape myrtle	*Prunus serrulata*	Flowering cherry
Liquidambar stryraciflua	Sweet gum	*Rhamnus californica* 'Eve Case'	California coffeeberry
Liriodendron tulipifera	Tulip tree	*Sequoia sempervirens*	Coast redwood
Loropetalum chinense	Loropetalum		

Principal Plants with Unknown Salt Tolerance			
Scientific name	**Common name**	**Scientific name**	**Common name**
Canna	Canna	*Juncus effusus* cvs.	Soft rush
Dicksonia antarctica	Tasmanian tree fern	*Juncus patens*	California grey rush
Geranium cultivars	Cranesbill		

4. Landscape irrigation

Landscape irrigation is being provided through a variety of systems including automatic spray, rotors, bubblers, and drip. Some areas receive no irrigation. Irrigation is under control of many different owners and managers. Soil moisture conditions varied widely among sites and were influenced by topography, soil profile and drainage characteristics, and irrigation application frequency and duration.

Most plants are more sensitive to sodium and chloride when the water is applied to the foliage than when applied to the soil and absorbed through roots. In general, tree foliage is unlikely to be hit by sprinklers because the tree canopies are above the application zone. Therefore, damage from direct foliage application is unlikely. Shrubs and ground covers are likely to be wetted by spray systems, and foliar injury of sensitive plants can be expected to occur with RWQCP recycled water at its current mineral content.

To avoid damage of sensitive plants to foliage-applied water, sodium concentrations should be maintained below 70 mg/l; for chloride, 100 mg/l. The RWQCP recycled water exceeds these thresholds (mean Na 221 mg/l; Cl 339 mg/l). Plants whose foliage is wetted then irrigated with RWQCP recycled water at its current mineral content are likely to be damaged. Drought stress occurs at higher soil moisture as water quality declines because the salts increase the osmotic pressure. As the soil dries, the salts in the soil solution become more concentrated, and plant damage is more likely to occur. In general, when converting from potable to recycled water, irrigation should be increased to maintain a moist soil. This recommendation applies to species that are not adapted to drought and have low to moderate salt tolerance. Most drought tolerant species have higher salt tolerance and usually can be maintained with recycled water under minimum irrigation regimes.

Recycled water that contains high concentrations of carbonates and carbonates tend to form precipitates with calcium, magnesium, and potassium. These precipitates cause additional wear on irrigation equipment such as valves, nozzles, and emitters. Drip irrigation emitters can become clogged by the carbonate precipitates. Water analyses for carbonate and bicarbonate were not available.

Leaching

Leaching is application of water to flush accumulated salts from the plant root zone. The leaching fraction (LF) is the amount of additional water (over the irrigation requirement) that should be applied to maintain an acceptable salt concentration in the root zone. It increases the amount of water applied to flush the salts that have accumulated in the soil below the plant roots. Rainfall contributes to leaching and usually reduces the LF or in some cases eliminates the need for leaching through irrigation, especially early in the warm season.

We estimate a leaching fraction of 10-20% may be needed to maintain soil salinity at concentrations suitable for plants having moderate salt tolerance. Other factors affecting the LF are on the amount of annual rainfall, and, soil texture and profile characteristics. To maintain soil salinity at concentrations suitable for plants having low salt tolerance, it is likely that leaching with potable water will be required. Site-specific leaching factors can be estimated using the WATSUIT model (http://esce.ucr.edu/soilwater/spring 2002.html).

Two site conditions that limit the effectiveness of leaching treatments are the very fine soil textures and presence of slowly permeable strata. The leach water must move away from the root zone to be effective. If it cannot, it may be necessary to install a sub-drain system to carry the saline leach water away from the landscape.

Anticipated response of landscapes to irrigation with recycled water

As described earlier, the response of the landscapes to irrigation with recycled water depends on the degree to which soil will become affected and the tolerance of plant materials to salts and specific ions. To determine the effects, water, plant, site characteristics and irrigation management must be considered (Table 7).

Water quality

The RWQCP recycled water at its present mineral content presents a moderate salinity hazard for landscape irrigation based on reported maximum and mean electrical conductivity (Ec_w), chloride and sodium concentrations. Boron, pH and SAR are not limiting to landscapes. Anticipated effects include:

Nitrogen	The nitrate component will enhance plant growth and reduce need for applied fertilizers.
Total salts, sodium, chloride	Gradual increase in soil salinity is expected. Damage likely to occur in sensitive plant species. Damage may occur to moderately tolerant species where salts accumulate in the soil over several years of irrigation.
Sodium	Gradual increase in soil sodium adsorption ratio (SAR) is expected. Decrease in soil permeability may occur with prolonged use.

Soil conditions

Soils across the project area varied with landscape position (landform) and were generally variable with depth, even on the same property. In general, the characteristics of soils examined were consistent with the descriptions of mapped soils in the 1958 survey (Gardner, et al.).

Water management considerations in irrigation with RWQCP recycled water include two major components: infiltration and drainage. To prevent salts from accumulating in the root zone, soils must be permeable enough to allow water (bearing salts in solution) to move through the profile, and the salt-laden waters must be able to move through and out of the root zone. Where sub-surface stratification is complex, or where water tables are near the surface, barriers to these processes occur.

Although sampling density was low, given the size of the project area and landform variability across the project area, some generalizations about soil compatibility with irrigation applications are possible:

- Because many of the lowland soils are very fine-textured (clays or clay loams) and overlie, in some cases, even finer textured horizons of older buried soils, restrictions to water infiltration and leaching of root zone profiles is expected.

These soils could be actively managed to allow appropriate leaching of salts and removal of saline leachate with the installation of extensive drainage infrastructure. These conditions are present at Mitchell Park, Clocktower, Theranos and parts of Hewlett Packard.

- Soils of the uplands (hillslopes and terraces) are generally gravelly and of somewhat coarser texture and underlain by gravelly strata. These soils probably can be managed to prevent excessive salt concentrations in the root zones because sufficient leaching fractions can be applied and drainage is adequate. These soils will require active monitoring if recycled waters are used on them.
- Soils at Tesla, Hewlett Packard, Termon Park, and VMWare (except for those underlain by heavy clay subsoils) probably can be managed to prevent excessive salt concentrations in the root zones and will require active monitoring.

Plant sensitivity to salts

Plants have a threshold for salt tolerance. Reaching that threshold depends on the initial salt concentration in soil, the degree to which salt accumulates under a given irrigation regime, the degree to which the plant is under physiological stress from heat, water deficit, and air pollution, soil conditions (depth, texture, structure, drainage), and the presence of other biotic problems such as insects and diseases.

- 35% (42 % of principal plants) have high salt tolerance. These plants are expected to maintain good appearance and health with appropriate irrigation with RWQCP recycled water.
- 39% (36% of principal plants) have moderate salt tolerance. These plants are expected to develop symptoms of salt stress when irrigated with RWQCP recycled water, especially in poorly drained soils. These plants may show some damage, but appearance will likely be acceptable when viewed from several feet away. Regular and thorough leaching will be required to maintain these plants.
- 21% (17% of principal plants) had low salt tolerance. Foliage damage to these plants is likely to be obvious and degrade plant. It is unlikely that leaching treatments using recycled water would be adequate to prevent plant damage.
- We do not anticipate notable changes to turf quality with introduction of recycled water as long as soil salinity and sodicity is managed. Turf often responds positively to the nutrient elements provided by recycled water. Fertilizer applications should be reduced when recycled water is applied.

Table 7: Summary of landscape conditions and expected response to irrigation with RWQCP recycled water. City of Palo Alto

Property	Landscape description	Plant palette salt tolerance (% of all taxa at property)				Soil conditions	Soil suitability for recycled water	Expected landscape response
		High	Moderate	Low	Unknown			
Theranos 3200 Hillview	Predominately drought tolerant plants managed with low irrigation; planted during redevelopment; mature pines retained.	38%	46%	10%	6%	Surface compacted, layered silty clay soil; parking lot island with fine sandy loam fill over native clay.	Problematic due to clay subsoil.	Minimal adverse effects expected to drought tolerant plants on low irrigation regimes. Low percentage of landscape expected to exhibit salt damage.
VM Ware 3401 Hillview	Mix of water demand from low to high; mature redwoods and pines retained during redevelopment; native oaks in non-irrigated area.	41%	34%	21%	4%	Surface compacted, gravelly clay	Problematic where clay subsoil is strong; moderate across rest of site.	Minimal adverse effects expected to majority of landscape. Redwoods and other salt sensitive species are expected to decline due to excess salt.
Clocktower 600-660 Hansen Way	Mature landscape, predominately moderate to high water requiring plants including redwoods.	23%	39%	35%	3%	Layered clays and gravelly clays, surface compacted.	Poor due to high clay content and possible high water table.	Substantial adverse effects expected due to high percentage of taxa having low and moderate salt tolerance and limited ability to leach accumulated salts from root zone. No notable change to taxa with high salt tolerance expected.
Mitchell Park 600 East Meadow Drive.	Mature landscape; wide range of species with varying water requirements; mature redwoods.	35%	45%	19%	1%	Deep clays.	Poor due to clay of surface and subsoil.	Substantial adverse effects expected due to high percentage of taxa having low and moderate salt tolerance and limited ability to leach accumulated salts from root zone. Effects on turf expected to be minimal if recommendations for soil management employed, No notable change to taxa with high salt tolerance expected.

Table 7, continued: Summary of landscape conditions and expected response to irrigation with RWQCP recycled water. City of Palo Alto

Property	Landscape description	Plant palette salt tolerance (% of all taxa at property)				Soil conditions	Soil suitability for recycled water	Expected landscape response
		High	Moderate	Low	Unknown			
Terman Park 695 Arastradero Rd.	Mature landscape; predominately turf. Plants at adjacent school included in inventory.	36%	36%	25%	3%	Deep gravelly clays, surface compacted	Moderately suitable; good drainage.	Minimal effects expected because site is predominately turf and soils can be leached.
Hewlett Packard, 3000 Hanover St.	Mature landscape; wide range of species with varying water requirements; mature redwoods; native oaks.	39%	35%	20%	6%	Deep gravelly clays, surface compacted	Moderately suitable in uplands; problematic in lower landscape positions.	Substantial effects expected to plants in lower landscape positions, including mature redwoods. No notable change to taxa with high salt tolerance expected.
Tesla Motors, 3500 Deer Creek Rd.	Recently renovated; wide range of species with varying water requirements; mature perimeter landscapes retained; native oaks.	45%	42%	13%	0%	Layered gravelly clays and clay loams, surface compacted.	Moderately suitable; good drainage.	Minimal effects expected to drought tolerant plants on low irrigation regimes. Low percentage of landscape expected to exhibit salt damage.

Opportunities and constraints for irrigating with RWQCP water

The trees and landscaping are valuable features, providing an enjoyable and healthy environment for the people who live, work and visit in the City of Palo Alto. Irrigating the landscapes with recycled water brings both opportunities and constraints.

Opportunities

- Recycled water contains nutrients, allowing reduction in application of fertilizers to landscapes.
- Over one-third of the plant species can be sustained with RWQCP recycled water with proper management. These are the plants identified a having high salt tolerance.
- Where landscapes receive minimal irrigation (such as much of Tesla Motors, VMWare, and Theranos properties), the total amount of salt introduced to the landscape is small and is unlikely to damage plants.
- Recycled water provides a “drought-proof” source of water for landscape irrigation.
- By using recycled water, potable water is conserved for other uses.
- Using recycled water for landscape irrigation helps meets the goals and requirements of the City of Palo Alto’s water conservation program and sustainability initiative.

Constraints

- Plants having low salt tolerance are likely to develop moderate to severe salt damage symptoms when irrigated regularly with RWQCP recycled water at its current mineral content. It is doubtful that the symptoms can be eliminated through leaching or soil management.
- Plants having moderate salt tolerance are likely to develop slight to moderate salt damage symptoms when irrigated regularly with RWQCP recycled water. In some cases the severity of the symptoms of moderately salt tolerant plants can be controlled through irrigation and soil management.
- Landscapes on lowland soils and soils where extensive filling over clay soils has taken place are expected to have the greatest degree of salt accumulation and consequent effect on moderately salt tolerant plants. Landscapes on upland soils (hillsides and terraces) are more easily leached and is it possible that moderately salt tolerant species could be maintained at those locations.
- More water will be required to maintain landscapes irrigated with recycled water than potable water to provide for leaching and to maintain soils in a moist condition. An exception is sites with minimal irrigation and species with high salt tolerance.
- Increased management costs will be incurred to monitor soil salinity, apply leaching and soil treatments, and manage irrigation to avoid water stress

- Development of stress-related pests is more likely when plants are under salt stress. Through pest monitoring and implementing pest management programs, plant injury can be minimized.
- Carbonate precipitates in recycled water tend to cause additional wear on irrigation equipment. Increased maintenance, repair and replacement often are required.

Recommendations for recycled water use at Palo Alto

1. RWQCP recycled water could be used as an irrigation source with changes in landscape management to monitor and react to increases in soil salinity and by replacing low salt tolerant plants with species having high salt tolerance. On lowland soils it may be necessary to replace some moderately salt tolerant species if appearance becomes unacceptable, and to install sub-drain systems to remove saline leachate.
2. The salinity hazard could be reduced if the recycled water quality was improved to maintain TDS below 1,000, Ec_w below 1500 µmohs/cm, chloride below 200 mg/l, and sodium below 150 mg/l. The salinity hazard could be eliminated if the recycled water quality was improved to maintain TDS below 650 mg/l, Ec_w below 1000 µmohs/cm, chloride below 100 mg/l, and sodium below 70 mg/l.
3. Monitor soil salinity and SAR through periodic soil analyses, preferably taken early, midway, and late in the irrigation season (approximately April, July, and October). The results of these analyses will guide the leaching and gypsum programs.
4. To avoid plant damage to salt sensitive landscape plants, implement a leaching program to maintain soil salinity within the root zone below 2.0 dS/m and SAR below 6.0. However, it is unlikely that soil salinity can be maintained below this level unless potable water is used for leaching. For moderately salt-tolerant plants, maintain soil salinity below 4.0 dS/m. Where subsoils do not drain adequately, installation of subsurface drainage systems may be recommended.

   Rainfall will satisfy a portion of the leaching requirement, depending on the rate, volume, and distribution through the season. The frequency with which leaching applications should be made depends on the several variables, and is triggered by approaching soil salinity thresholds defined above.
5. Apply gypsum prior to leaching when indicated by soil analysis. Gypsum ($CaSO_4$) is a soil amendment that, when combined with leaching, helps lower soil sodium concentrations. Gypsum application should be considered when soil analyses reveal one or more of the following conditions: SAR exceeds 6.0, SAR increases 2 units or more (e.g. 2.3 to 4.3), and/or sodium concentration exceeds 5 meq/l (115 mg/l). The amount of gypsum needed and the frequency of application depend on site-specific soil and water characteristics, and are determined by laboratory analysis.
6. When using recycled water, irrigation frequency should be adjusted as needed to maintain moist soil. Drought stress occurs at higher soil moisture as water quality declines because the salts increase the osmotic pressure. As the soil

dries, the salts in the soil solution become more concentrated, and plant damage is more likely to occur. Irrigation systems with non-uniform application patterns may need to be upgraded to avoid dry areas.

7. For plants that are not adapted to prolonged drought, avoid minimal irrigation strategies that result in dry soils and plant water stress. Minimum irrigation strategies are neither necessary nor beneficial when applying recycled water. It is important to maintain a relatively moist soil to dilute salts in the soil.
8. Perform an irrigation system audit to quantify application rates and variation in application pattern. This information is needed to schedule irrigation and leaching programs and to identify potential problem areas that need modification.
9. Modify irrigation systems to avoid wetting plant foliage during operation. Adjust spray patterns on sprinkler systems to lower the trajectory.
10. Consider installing soil moisture monitoring equipment to measure the soil moisture at various depths within and below plant root zones. This information would be helpful in evaluating effectiveness of irrigation schedules and leaching treatments.

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HortScience, Inc.

Nelda Matheny
Horticultural Consultant

Appendices

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Evaluating Water Quality

Appendix 2
Water Analyses

Appendix 3
Site Evaluation: Soil Assessment

Appendix4
Soil Analyses

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Site Evaluation: Plant Assessment

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Appendix 1

Evaluating Water Quality for Landscape Irrigation

Irrigating landscapes with recycled water is an important component of California's efforts to conserve our water resources. By applying recycled water to landscapes, potable water is conserved for human consumption.

Wu and others (2009) stated that a necessary safeguard during the design of an urban reclaimed water distribution system is that, "The recycled water agency must assure that the reclaimed water delivered to the customer meets the water quality standards for the intended uses."

Recycled water contains salts that, over time, can damage sensitive plants and degrade soil quality (Costello and others 2003, Harivandi 2000, Matheny and Clark 1998, Miyamoto 2008, Qian and Mecham 2005, Qian 2006, Tanji and others 2009, Wu and others 2009). Some plants are more sensitive to salts than humans, so state and federal water quality standards developed to protect humans and wildlife may not be adequate to protect plants.

The water that we drink (potable water) has a number of constituent ions or salts. Some of these constituents can affect plant growth, health, and appearance. In the context of landscape irrigation, water quality is evaluated as a function of the concentration of total salts [referred to as total dissolved solids (TDS) or electrical conductivity (ECw)] as well as the concentration of several specific ions (chloride, sodium, boron), bicarbonate, pH, trace elements, and nutrients (nitrogen, phosphorus, potassium) (Table 1). Some plants are more sensitive to salts than humans, so state and federal water quality standards may not adequately protect plants.

In this narrow sense, good quality water has relatively few salts, while poor quality water has higher concentrations. Seawater, for example, is of poor quality and damaging to landscape plants. The sources of the best quality water in the Bay Area include surface flow from rainfall and snow melt (such as Hetch Hetchy water). Sources of poorer quality waters include shallow aquifers where salts have accumulated over thousands of years; deeper wells tend to have lower concentrations of salts. Many municipal water sources are blends of surface and deep aquifer waters which provide a satisfactory water quality for human consumption.

While good quality water is suitable for use for irrigation of most any plant, poorer quality water may inhibit plant growth or affect health and appearance of some plants. As water moves through the soil and is evaporated from the soil surface, some of the salts in the water stay behind. When present in high concentrations, some of these salts can damage sensitive plants. In some cases the salts can cause plant damage when water is applied directly to the foliage by sprinklers.

Table 1: Water quality constituents important to landscapes

Component	**Parameter measured**	**Units of measurement**	**Potential effects on landscape**
Salts	Total dissolved solids (TDS); electrical conductivity (ECw);	TDS: parts per million (ppm), milligrams per liter (mg/l) ECw: milimhos per centimeter (mmhos/cm), micromhos per centimeter (µmhos/cm), decisiemens per meter (dS/m) or Siemens per meter (S/m)	When water is applied to soils, some of the salts in the water remain in the soil. As these salts accumulate in the soil, damage to sensitive plants may occur. Salt toxicity is first expressed as stunting of growth and yellowing of foliage. Burning of the edge of the leaves and defoliation usually follows. In severe cases, plants are killed. The degree of the problem depends on the sensitivity of the plant to salts and the concentration of the accumulated salts in the soil. Salts may also be absorbed through the leaves if the foliage is wetted. Plant damage usually occurs at a lower concentration of salts when water is applied to the foliage compared to the soil.
Specific ions	Chloride (Cl), sodium (Na) and boron (B)	ppm, milliequivalent per liter (meq/l)	While salinity expresses the total salt content, it will not adequately identify potential toxicities from specific ions. Chloride (Cl), sodium (Na) and boron (B) are the primary ions of concern. Sodium and chloride toxicity will occur at lower concentrations when the water is applied to plant foliage (as with sprinklers) than when applied to the soil and absorbed through roots
Sodium adsorption ratio (SAR)	Calculation: $SAR = Na \div \sqrt{\frac{Ca + Mg}{2}}$	Components in calculation are in meq/l; SAR has no units	In addition to affecting plants directly, sodium can have negative effects on soil structure. It may cause dispersion of soil aggregates if present in high concentrations. This decreases both drainage and soil aeration which may cause plant decline and death. Soils high in clay are particularly susceptible to breakdown of aggregates by sodium. The permeability problems that can be caused by a high SAR can be partially offset by salts in the water. Therefore, SAR is evaluated in combination with the ECw.
Bicarbonate	HCO_3^-	mg/l, ppm, meq/l	High bicarbonate increases the effect of the available sodium in the water and its potential effect on sodium levels in the soil and plants. This occurs when precipitates form from bicarbonate ions combined with calcium and/or magnesium carbonates. Formation of the precipitates removes calcium from the soil solution, increasing the SAR.
Residual sodium carbonate (RSC)	Calculation: $RSC=(HCO_3+CO_3) - (Ca+Mg)$	meq/l	This calculation identifies the bicarbonate hazard to soils. The higher the number, the greater the hazard.

Component	Parameter measured	Units of measurement	Potential effects on landscape
Residual chlorine	Free and combined chlorine (Cl)	ppm, mg/l	Excessive amounts of free available Cl_2 may cause leaf-tip burn and damage sensitive plants. However, most chlorine in recycled water is in a combined form, which does not cause plant damage.
Hydrogen ion activity	pH	no units	Unit of measure that describes the alkalinity or acidity of a solution. Negative log of the hydrogen ion concentration. Measured on a scale for 0 to 14.The pH of water affects metal solubility (e.g. Fe, Mn, Zn, Al) as well as alkalinity of soils.
Heavy metals	Specific elements (e.g. Cd, Zn, Ni, Hg)	mg/l, ppm	Some heavy metals accumulated in the environment and are toxic to plants. Primary concern is for plants with high levels that are ingested by animals.
Nutrients	Nitrogen (N), phosphorus (P) potassium (K)	mg/l, ppm	N, P and K are essential nutrients for plant growth, and their presence normally enhances the value of water for irrigation. When discharged into the aquatic environment, N and P can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, N can lead to the pollution of groundwater.

FAO water quality guidelines (Ayers and Westcot 1985), which were developed for agricultural uses, commonly are applied to landscapes. Although agricultural cropping systems and landscapes have some characteristics in common, there are significant dissimilarities too. Landscapes are comprised of a wide range of species rather than a single crop, are planted in highly modified, variable, and often degraded soils rather than prime agricultural soil, and are long-lived rather than replanted each year. Furthermore, successful landscapes are judged by their appearance and function rather than by the amount of food or growth they produce.

We recommend evaluating water quality applied to landscapes based on the tolerance of the plant materials to salts in the specific water source and degree to which soil is expected to become degraded. Four categories of water quality are defined.

Category 1: Good water quality with no restrictions on site use.

Category 2: Moderate water quality that is appropriate for all landscapes except those with salt and/or boron sensitive plants and poorly drained soils that cannot be leached.

Category 3: Fair water quality that can be used where plants have at least moderate salt and/or boron tolerance and soils are at least moderately drained; landscapes on poorly drained sites must be comprised of plants with good salt and/or boron tolerance.

Category 4: Poor water quality that is appropriate only for sites having salt and/or boron tolerant plants and moderate to good drainage.

The poorer the water quality, the less suitable it is for use at sites with heavy soils and salt-sensitive plants. For example, prolonged irrigation with Category 2, 3, or 4 water would damage salt sensitive species such as coast redwood (Oster 2009). Soils with complex structures (including compacted layers) and stratified horizons will respond differently to water application and throughflow, so permeability of the root zone is another factor affecting use and efficacy of recycled water used for irrigation.

According to Grieve and others (2007), "It is not adequate only to identify maximum TDS or EC_w for use in landscapes containing salt-sensitive species; limits for sodium, chloride, boron, and RSC must also be established." Therefore, ranges for each of these components in each of the four water quality categories are identified in Table 2. These ranges were derived from a review of the scientific literature, as well as our experience over the last 20 years evaluating and analyzing soil, water, and tissue samples from landscape irrigated with recycled water.

Table 2: Interpretive guidelines for recycled water quality for landscape irrigation.

Parameter	Category 1	Category 2	Category 3	Category 4
Salinity hazard[a]	None	Slight	Moderate	Severe
TDS, mg/l	<650[b,c]	650-1,000	1,000-2,000	>2,000
EC_w, dS/m	<1.0[f]	1.0-1.5	1.5-3	>3.0[i,]
Specific ion toxicity				
Boron (mg/l)	<0.5	0.5-1.0	1.0-3.0	>3.0[g,i]
Chloride (mg/l)[a,d,e]	<100	100-200	200-350	>350
Sodium (mg/l)[a,d,e]	<70	70-150	150-250	>250
Sodium adsorption ratio (SAR)[a,l,j]				
If SAR is:	and EC_w is[k]:			
0-3	>0.7	0.7-0.5	0.4-0.2	<0.2
3-6	>1.2	1.2-0.8	0.7-0.3	<0.3
6-12	>1.9	1.9-1.2	1.1-0.5	<0.5
12-20	>2.9	2.9-2.1	2.0-1.3	<1.3
Residual sodium carbonate (meq/l)[i]	<1.25	1.25-2.0	2.0-2.5	>2.5
Bicarbonate (mg/l)[a,i]	<90	90-200	200-500	>500
Residual chlorine (mg/l)[h,i]	<1.0	1-2.5	2.5-5.0	>5.0

[a]Morris and Devitt, 2002
[b]Oster 2009
[c]Barnes, Oki and Evans 2007
[d]Devitt and others 2005
[e]Myamoto and others 2004
[f]Miyamoto and others 2001
[g]Tanji and others 2007
[h]Cayanan and others 2008
[i]Ayers and Westcott 1985
[j]Harivandi 2004

[k]To use table, find SAR of water within ranges listed; along that line, identify the EC_w. The column in which the EC_w appears identifies the Category. For instance, if the SAR is 4 and the EC_w is 1.1, the SAR is in Category 2.

When assessing water quality it may be found that more than one category is represented. For instance, the salinity may place the water in Category 2; the SAR, in Category 1. In this case the highest, Category 2, would be used. Some parameters are more important than others, however. The parameters in Table 2 are listed in approximate order of importance: salinity and specific ions are most important, followed by SAR, and then by residual sodium carbonate and bicarbonate. If the water salinity were in Category 2 and the bicarbonate in Category 3, we suggest classifying the water in Category 2.

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Appendix 2: Palo Alto Recycled Water Data: 2008 through mid-2010

SAMPDATE	SAMPTYPE	TEST	REPORTRESU	ANALYST	COMMENT
9/10/2008	GRAB	COND	1580	JJ t	
9/10/2008	GRAB	PH	6.8	JJ t	@12:30pm
9/10/2008	GRAB	PO4	15	JJ t	
10/8/2008	GRAB	COND	1580	SB t	
10/8/2008	GRAB	PH	6.7	KY	@0857
10/8/2008	GRAB	PO4	16	JJ t	
11/5/2008	GRAB	ALKA	86	SB t	
11/5/2008	GRAB	B	.34	ALPHA LAB	
11/5/2008	GRAB	COND	1600	GW t	
11/5/2008	GRAB	Ca	46	ALPHA LAB	
11/5/2008	GRAB	Cl-	317	GW t	
11/5/2008	GRAB	HARD	240	SB t	
11/5/2008	GRAB	K	17	ALPHA LAB	
11/5/2008	GRAB	Mg	37	ALPHA LAB	
11/5/2008	GRAB	Mn	17	ALPHA LAB	ug/l
11/5/2008	GRAB	Mo	8.2	ALPHA LAB	ug/l
11/5/2008	GRAB	NO3	23	ALPHA LAB	
11/5/2008	GRAB	Na	210	ALPHA LAB	mg/l
11/5/2008	GRAB	PH	6.8	JJ t	@07:49am
11/5/2008	GRAB	PO4	15	JJ t	
11/5/2008	GRAB	SAR	5.58	ALPHA LAB	
11/5/2008	GRAB	SO4	84	ALPHA LAB	
11/5/2008	GRAB	TDS	920	GW t	
4/23/2009	GRAB	COND	1680	SB t	
4/23/2009	GRAB	PH	6.8	SB t	@ 10:45 am
4/23/2009	GRAB	PO4	13	SB	
4/27/2009	GRAB	TURB	1.0	SB t	
5/6/2009	GRAB	ALKA	98.3	TL	
5/6/2009	GRAB	B	.33	ALPHA LAB	mg/l
5/6/2009	GRAB	COND	1670	GW t	
5/6/2009	GRAB	Ca	52	ALPHA LAB	INHOUSE = 43.2mg/l
5/6/2009	GRAB	Cl-	344	RH t	
5/6/2009	GRAB	HARD	272	TL	
5/6/2009	GRAB	K	16	ALPHA LAB	mg/l
5/6/2009	GRAB	Mg	39	ALPHA LAB	mg/l
5/6/2009	GRAB	Mn	24	ALPHA LAB	ug/l
5/6/2009	GRAB	Mo	8.9	ALPHA LAB	ug/l
5/6/2009	GRAB	NO3	24	ALPHA LAB	mg/l
5/6/2009	GRAB	Na	200	ALPHA LAB	mg/l
5/6/2009	GRAB	PH	6.8	SB t	@ 08:14 am
5/6/2009	GRAB	PO4	12	SB	
5/6/2009	GRAB	SAR	5.17	ALPHA LAB	
5/6/2009	GRAB	SO4	94	ALPHA LAB	mg/l
5/6/2009	GRAB	Si	14	ALPHA LAB	
5/6/2009	GRAB	TDS	940	RH t	
5/7/2009	GRAB	TURB	0.92	GW t	Meter reading 0.94
6/10/2009	GRAB	COND	1700	KY	Sampled from RP CCT overflow
6/10/2009	GRAB	PH	6.5	KY	@1218
6/11/2009	GRAB	COND	1670	TL	
6/11/2009	GRAB	PH	6.8	SB t	@ 10:16 am
6/11/2009	GRAB	PO4	13	SB t	
7/6/2009	GRAB	COND	1780	SB t	

Appendix 2: Palo Alto Recycled Water Data: 2008 through mid-2010					
SAMPDATE	SAMPTYPE	TEST	REPORTRESU	ANALYST	COMMENT
7/6/2009	GRAB	Cl-	384	RH t	
7/6/2009	GRAB	PH	6.6	SB t	@ 08:38 am
7/6/2009	GRAB	PO4	14	SB t	
7/6/2009	GRAB	SALIN	0.9	TL	
8/5/2009	GRAB	ALKA	84.7	TL	
8/5/2009	GRAB	B	.32	ALPHA LAB	mg/l
8/5/2009	GRAB	COND	1600	ALPHA LAB	INHOUSE 1680 umhos/cm by SB
8/5/2009	GRAB	Ca	43	ALPHA LAB	INHOUSE 39.8mg/l by TL
8/5/2009	GRAB	Cl-	356	RH t	
8/5/2009	GRAB	HARD	252	TL	
8/5/2009	GRAB	K	16	ALPHA LAB	mg/l
8/5/2009	GRAB	Mg	35	ALPHA LAB	mg/l
8/5/2009	GRAB	Mn	21	ALPHA LAB	ug/l
8/5/2009	GRAB	Mo	9.5	ALPHA LAB	ug/l
8/5/2009	GRAB	NO3	24	ALPHA LAB	mg/l
8/5/2009	GRAB	Na	190	ALPHA LAB	mg/l
8/5/2009	GRAB	PH	6.5	TL	@0741
8/5/2009	GRAB	PO4	13	SB t	
8/5/2009	GRAB	SALIN	0.9	CALTEST	ppt.Inhouse 0.8ppt by SB 8/14/2009;Caltest was 0.86ppt
8/5/2009	GRAB	SAR	5.35	ALPHA LAB	
8/5/2009	GRAB	SO4	87	ALPHA LAB	mg/l
8/5/2009	GRAB	Si	15	ALPHA LAB	mg/l
8/5/2009	GRAB	TDS	1000	RH t	TDS Meter = 840
9/3/2009	GRAB	ALKA	93	SB t	Analyzed on 9/3/2009
9/3/2009	GRAB	COND	1740	KY	
9/3/2009	GRAB	Ca	50	ALPHA LAB	mg/l
9/3/2009	GRAB	Cl-	353	KY	
9/3/2009	GRAB	HARD	260	SB t	
9/3/2009	GRAB	Mg	39	ALPHA LAB	mg/l
9/3/2009	GRAB	Na	230	ALPHA LAB	mg/l
9/3/2009	GRAB	PH	6.6	GW t	@0859
9/3/2009	GRAB	PO4	14	KY	
9/3/2009	GRAB	SALIN	0.92	CALTEST	ppt. INHOUSE 0.9ppt by KY 9/10/2009
9/3/2009	GRAB	TDS	970	KY	
10/8/2009	GRAB	COND	1740	KY	
10/8/2009	GRAB	Ca	42	TESTAM	Inhouse 43ppm by SB.
10/8/2009	GRAB	Cl-	354	KY	
10/8/2009	GRAB	Mg	34	TESTAM e	
10/8/2009	GRAB	Na	240	TESTAM e	mg/L
10/8/2009	GRAB	PH	6.7	KY	@0830
10/8/2009	GRAB	PO4	14	KY	
10/8/2009	GRAB	SALIN	0.9	KY	
10/8/2009	GRAB	TDS	990	TESTAM e e	
11/5/2009	GRAB	ALKA	105	SB t	
11/5/2009	GRAB	B	0.35	TESTAM e	
11/5/2009	GRAB	COND	1670	SB t	
11/5/2009	GRAB	Ca	48	TESTAM e	
11/5/2009	GRAB	Cl-	336	KY	
11/5/2009	GRAB	HARD	265	SB t	

Appendix 2: Palo Alto Recycled Water Data: 2008 through mid-2010					
SAMPDATE	SAMPTYPE	TEST	REPORTRESU	ANALYST	COMMENT
11/5/2009	GRAB	K	17	TESTAM e	mg/l
11/5/2009	GRAB	Mg	35	TESTAM e	mg/l
11/5/2009	GRAB	Mn	35	TESTAM e	ug/l
11/5/2009	GRAB	Mo	<2	TESTAM e	ug/l
11/5/2009	GRAB	NO3	24	TESTAM e	mg/l
11/5/2009	GRAB	Na	220	TESTAM e	mg/l
11/5/2009	GRAB	PH	6.6	KY	@0801
11/5/2009	GRAB	PO4	14	KY	
11/5/2009	GRAB	SALIN	0.8	TL e	
11/5/2009	GRAB	SAR	5.9	TESTAM e	
11/5/2009	GRAB	SO4	100	TESTAM e	mg/l
11/5/2009	GRAB	Si	6.7	TESTAM e	mg/l
11/5/2009	GRAB	TDS	950	TESTAM e	
12/4/2009	GRAB	B	.45	GW t	MDL STUDY
12/4/2009	GRAB	COND	1590	TL	
12/4/2009	GRAB	Ca	44	TESTAM	INHOUSE 42.2mg/l SB
12/4/2009	GRAB	Cl-	336	SB t	
12/4/2009	GRAB	Mg	31	TESTAM e	mg/l
12/4/2009	GRAB	Na	210	TESTAM e e	mg/l
12/4/2009	GRAB	PH	6.6	TL	@0830
12/4/2009	GRAB	PO4	13	SB t e	
12/4/2009	GRAB	SALIN	0.8	SB t	
12/4/2009	GRAB	TDS	950	TESTAM e	
1/12/2010	GRAB	COND	1760	RH t	
1/12/2010	GRAB	Ca	64	TESTAM e	mg/l
1/12/2010	GRAB	Cl-	333	TL	
1/12/2010	GRAB	Mg	40	TESTAM e	mg/l
1/12/2010	GRAB	Na	240	TESTAM e	mg/l
1/12/2010	GRAB	PH	7.2	RH t	Analysed at 8:14AM
1/12/2010	GRAB	PO4	15	TL	
1/12/2010	GRAB	SALIN	0.9	TL	ppt
1/12/2010	GRAB	TDS	1000	TESTAM e	
2/10/2010	GRAB	ALKA	196	SB t	
2/10/2010	GRAB	B	0.36	TESTAM e	mg/l
2/10/2010	GRAB	COND	1740	TL	
2/10/2010	GRAB	Ca	64	TESTAM e	mg/l
2/10/2010	GRAB	Cl-	323	TL	
2/10/2010	GRAB	HARD	297	MW t	
2/10/2010	GRAB	K	15	TESTAM e	mg/l
2/10/2010	GRAB	Mg	41	TESTAM e	mg/l
2/10/2010	GRAB	Mn	32	TESTAM e	ug/l
2/10/2010	GRAB	Mo	<20	TESTAM e	ug/l
2/10/2010	GRAB	NO3	19	TESTAM e	mg/l
2/10/2010	GRAB	Na	220	TESTAM e	mg/l
2/10/2010	GRAB	PH	6.9	RH t	Analysed @9:00am
2/10/2010	GRAB	PO4	12	TL	
2/10/2010	GRAB	SALIN	0.99	TESTAM	ppt. INHOUSE=0.9ppt
2/10/2010	GRAB	SAR	5.3	TESTAM e	
2/10/2010	GRAB	SO4	150	TESTAM e	mg/l
2/10/2010	GRAB	Si	8.8	TESTAM e	mg/l
2/10/2010	GRAB	TDS	1000	TESTAM e	
3/4/2010	GRAB	COND	1660	GW t	

Appendix 2: Palo Alto Recycled Water Data: 2008 through mid-2010

SAMPDATE	SAMPTYPE	TEST	REPORTRESU	ANALYST	COMMENT
3/4/2010	GRAB	Ca	56	TESTAM e e	mg/L
3/4/2010	GRAB	Cl-	308	TL	
3/4/2010	GRAB	Mg	42	TESTAM e e	mg/L
3/4/2010	GRAB	Na	220	TESTAM e e	mg/L
3/4/2010	GRAB	PH	6.9	RH t	Analysed at 9:55am
3/4/2010	GRAB	PO4	9.8	TL e e e	
3/4/2010	GRAB	SALIN	0.8	GW t	ppt
3/4/2010	GRAB	TDS	980	TESTAM e	mg/L
4/14/2010	GRAB	ALKA	143	TL	
4/14/2010	GRAB	COND	1518	AV t	
4/14/2010	GRAB	Ca	50	TESTAM e	mg/l
4/14/2010	GRAB	Cl-	312	AV t	
4/14/2010	GRAB	Mg	37	TESTAM e	mg/l
4/14/2010	GRAB	Na	170	TESTAM e	mg/l
4/14/2010	GRAB	PH	7.1	AV t	@0825
4/14/2010	GRAB	PO4	9.5	SP	
4/14/2010	GRAB	SALIN	0.7	TL	ppt
4/14/2010	GRAB	TDS	870	TESTAM e	
5/13/2010	GRAB	ALKA	119	AV t	
5/13/2010	GRAB	B	0.33	TESTAM e	mg/l
5/13/2010	GRAB	COND	1652	AV t	
5/13/2010	GRAB	Ca	48	TESTAM e	mg/l
5/13/2010	GRAB	Cl-	320	AV t e e e	
5/13/2010	GRAB	HARD	277	AV t	
5/13/2010	GRAB	K	15	TESTAM e	mg/l
5/13/2010	GRAB	Mg	34	TESTAM e	mg/l
5/13/2010	GRAB	Mn	0.089	TESTAM e	mg/l
5/13/2010	GRAB	Mo	<0.02	TESTAM e	mg/l
5/13/2010	GRAB	NO3	26	TESTAM e e	
5/13/2010	GRAB	Na	200	TESTAM e	mg/l
5/13/2010	GRAB	PH	6.8	TL	@0646
5/13/2010	GRAB	PO4	12	RH t e e e	
5/13/2010	GRAB	SALIN	0.8	AV t	ppt
5/13/2010	GRAB	SAR	5.4	TESTAM e e	
5/13/2010	GRAB	SO4	110	TESTAM e e	
5/13/2010	GRAB	Si	6.5	TESTAM e	mg/l
5/13/2010	GRAB	TDS	1000	TESTAM e e	
6/9/2010	GRAB	ALKA	115	AV t	Analyzed 6/21/10
6/9/2010	GRAB	COND	1620	AV t	
6/9/2010	GRAB	Ca	49	TESTAM e	mg/l
6/9/2010	GRAB	Cl-	358	AV t	
6/9/2010	GRAB	Mg	36	TESTAM e	mg/l
6/9/2010	GRAB	Na	210	TESTAM e	mg/l
6/9/2010	GRAB	PH	6.8	TL	@0812
6/9/2010	GRAB	PO4	14	SP	
6/9/2010	GRAB	SALIN	0.8	AV t	ppt
6/9/2010	GRAB	TDS	940	TESTAM e	
7/7/2010	GRAB	ALKA	117	AV t	
7/7/2010	GRAB	COND	1674	AV t	
7/7/2010	GRAB	Ca	45	TESTAM e	mg/l
7/7/2010	GRAB	Cl-	351	AV t	
7/7/2010	GRAB	Mg	33	TESTAM e	mg/l

Appendix 2: Palo Alto Recycled Water Data: 2008 through mid-2010

SAMPDATE	SAMPTYPE	TEST	REPORTRESU	ANALYST	COMMENT
7/7/2010	GRAB	Na	210	TESTAM e	mg/l
7/7/2010	GRAB	PH	7.0	TL	@0750
7/7/2010	GRAB	PO4	13	RH t	
7/7/2010	GRAB	SALIN	0.8	AV t	ppt
7/7/2010	GRAB	TDS	970	TESTAM e	
8/4/2010	GRAB	ALKA	94	AV t	Analyzed on 8/13/10
8/4/2010	GRAB	B	0.31	TESTAM e	mg/l
8/4/2010	GRAB	COND	1546	AV t	
8/4/2010	GRAB	Ca	41	TESTAM e	mg/l
8/4/2010	GRAB	HARD	246	KY	
8/4/2010	GRAB	Mg	32	TESTAM e	mg/l
8/4/2010	GRAB	Mn	.058	TESTAM e	mg/l
8/4/2010	GRAB	Mo	<.02	TESTAM e	mg/l
8/4/2010	GRAB	NO3	22	TESTAM e	mg/l
8/4/2010	GRAB	Na	200	TESTAM e	mg/l
8/4/2010	GRAB	PH	6.7	TL	@0750
8/4/2010	GRAB	SALIN	0.9	TESTAM	Inhouse=0.8ppt
8/4/2010	GRAB	SAR	5.7	TESTAM e	
8/4/2010	GRAB	SO4	82	TESTAM e	
8/4/2010	GRAB	Si	14	TESTAM e	mg/l
8/4/2010	GRAB	TDS	960	TESTAM e	
8/26/2010	GRAB	PH	6.9	TL	@0730

Appendix 3
Site Evaluation

Soil Investigation #1
Theranos

Location: 3200 Hillview
S/W corner property near Arten Road
Description: Large valley oak directly across road (west) presumably at original grade
Vegetation: Predominately drought tolerant plantings

Left: Sample site (note native oak in background)
Right: Redox and charcoal in transition between native

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-2"	Silt loam	Compacted, platy		Common roots	High in organic matter (amendment)
	6-9"	Silt loam		Moist		A combination of organic materials (bark, stems, etc.)
	9-12"	Silt loam		Slightly moist		Common redox; charcoal in transition zone between old landscape surface and new fill materials
	12-13"	Silty clay loam		Very moist	Few roots	
	13-16"	Silty clay		Moist	Few decomposed roots	Dark; common redox; apparent old surface
	16-24"	Silty clay loam		Slightly moist	One large dead root to 3/4"in diameter	Common redox; common reduced mottles
	24-27"	Silty clay loam		Wet	Common decomposed roots	Common redox
	27-30"	Silty clay loam		Dry	Few roots	Common redox
	30 to >36"	Clay		Slightly moist	Few old root traces	Common reduced mottles

Chemical Analyses*

	1A	1B	1C
Depth of sample	6-12"	18-24"	30-36"
pH	6.7	6.3	6.8
ECe (mmhos/cm)	0.6	0.3	0.3
Sodium (meq/l)	1.0	1.5	1.1
Chloride (meq/l)	0.6	1.4	0.8
Boron (ppm)	0.2	0.3	0.2
SAR	0.7	1.5	1.2

Sampled June 9, 2010

Appendix 3
Site Evaluation

Soil Investigation #2
Theranos

Location: 3200 Hillview
East parking lot island
Description: Fill materials in island over heavy clay
Vegetation: Drought-tolerant vegetation
Young oaks in poor condition

Site #2. Note poor condition of trees in parking lot island.

Left: 14" fill soil overlaid compacted clay. Roots were primarily limited to fill soils, which were dry.

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-4"	Clay loam	Compacted	Dry	Profuse roots (Root mat from Dietes)	
	4-12"	Fine sandy loam		Very dry	Common roots	Mixed yellow fill materials; occasional gravel to 1" diameter
	12-14"	Fine sandy loam		Slightly moist	Common roots	Occasional gravels
	14-24"	Clay		Slightly moist	Few roots	Abrupt change; presumably old surface of cut; common gleyed mottles

Chemical Analyses

Sample #	2A	2B
Depth of sample	6-12"	14-20"
pH	7.1	7.4
ECe (mmhos/cm)	0.3	0.2
Sodium (meq/l)	1.2	1.1
Chloride (meq/l)	0.6	0.6
Boron (ppm)	0.2	0.1
SAR	1.2	1.9

Sampled June 9, 2010

Appendix 3
Site Evaluation

Soil Investigation #3
VMWare

Location: 3401 Hillview
Along Hillview, east side of property

Description: Apparent original surface; slope, hill, ridge; dry throughout

Vegetation: Natvie oaks, grasses, redwoods, California pepper

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-6"	Gravelly clay or gravelly clay loam	Platy; surface compaction	Dry	Common roots	Slightly dark
	6-12"	Gravelly clay	Angular, blocky	Dry	Few roots	Common gravels to 1"
	12-18"	Gravelly clay	Angular, blocky	Dry	Few roots	Common gravels to 1"
	18-20"	Gravelly clay (probably upper regolith)		Dry	No roots	Light tan transition zone
	20 to >24"	Gravelly clay		Dry	No roots	>60% gravels

Chemical Analyses

Sample #	3A	3B
Depth of sample	6-12"	14-20"
pH	5.8	6.1
ECe (mmhos/cm)	0.2	0.2
Sodium (meq/l)	1.0	1.0
Chloride (meq/l)	0.6	0.8
Boron (ppm)	0.4	0.3
SAR	1.3	1.7

Sampled June 9, 2010

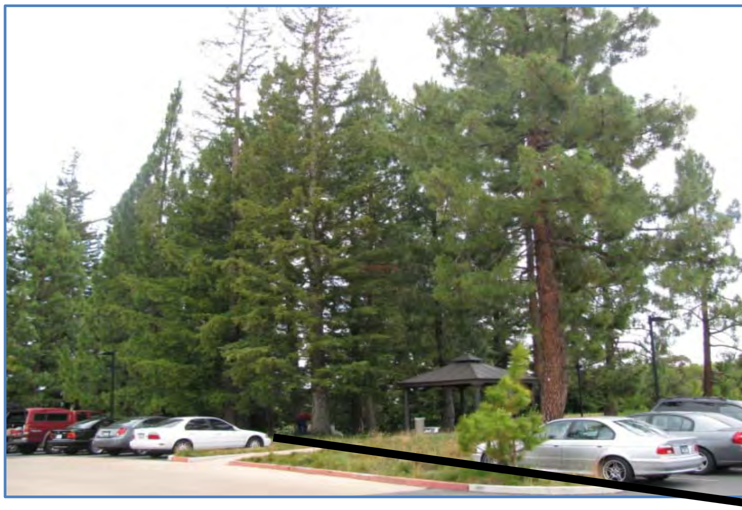
Soil Investigation #4
VMWare

HORT SCIENCE

Location: 3401 Hillview
West side

Description: Looks like scalped surface, probably original surface
dry throughout

Vegetation: Mature pines and redwoods retained in redevelopment
Roots injured during grading and construciton
Fescue groundcover in poor condition due to lack of water



Above: Mature redwoods showing signs of water stress.

Right: Redwood roots cut during grading and parking lot construction.

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-6"	Gravelly clay	Compacted surface	Dry	>75% roots	Dark
	6 to >18"	Gravelly clay		Dry	Large roots to >3/4"	Tan

Chemical Analyses

	4A
Depth of sample	6-12"
pH	5.5
ECe (mmhos/cm)	0.4
Sodium (meq/l)	1.8
Chloride (meq/l)	1.8
Boron (ppm)	0.4
SAR	1.6

Sampled June 9, 2010

Soil Investigation #5
VMWare

Location: 3401 Hillview
Parking lot island, west of Bldg. #3407
Description: Bark duff layer at surface; moist, dry gravelly clay below
Vegetation: Young redwoods, Lantana groundcover

Above: Site #5 in new parking lot planter.
Right: Young redwood with limited root

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-4"	Gravelly clay	Compacted, platy	Very moist	Few roots	
	4-10"	Gravelly clay	Massive	Moist	Few roots	
	10-16"	Gravelly clay		Moist	Few roots	Some inclusions of darker clay
	16 to > 24"	Gravelly clay	Massive	Dry	No roots	

Chemical Analyses

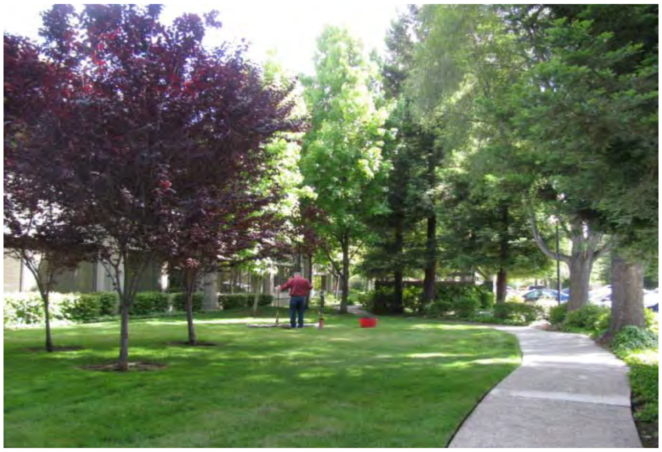
	5A	5B
Depth of sample	6-12"	12-24"
pH	8.0	7.6
ECe (mmhos/cm)	0.4	0.6
Sodium (meq/l)	1.8	2.5
Chloride (meq/l)	0.8	1.0
Boron (ppm)	0.3	0.1
SAR	1.9	2.1

Sampled June 9, 2010

Appendix 3
Site Evaluation

Soil Investigation #6
Clocktower

Location: 600-660 Hanson Way
Landscape area between building and N parking lot
Description: This site is fill over old marsh or channel
Vegetation: Shady environment with pond; mature landscape
High water requiring plants including redwoods



Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-6"	Clay	Compacted, platy	Dry	Common roots; some roots to 1/2" in diameter	Upper inch moist with turf roots; dry below
	6-14"	Gravelly clay		Dry	Common roots to 3/4"	Possible fill
	14-18"	Clay		Dry	Few roots	Common gravels
	18-26"	Dark organic clays		Dry	Common roots	Common organic materials
	26-28"	Clay		Slightly moist	High concentration of roots	Few gravels
	28 to>32"	Gravelly clay		Moist	Common roots	

Chemical Analyses

	6A	6B	6C
Depth of sample	6-12"	14-18"	18-26"
pH	7.4	7.5	7.5
ECe (mmhos/cm)	0.5	0.7	0.7
Sodium (meq/l)	1.7	2.2	2.3
Chloride (meq/l)	0.8	1.6	1.4
Boron (ppm)	0.1	0.2	0.2
SAR	1.4	1.5	1.4

Sampled June 10, 2010

Soil Investigation #7
Mitchell Park

Location: 3800 Middlefield Road
Northwest end of park near Meadow Dr.
Description: Flat turf area 40' from redwoods and 20' from Cape chestnut street trees
Vegetation: Mature trees in good condition

Left: Site #7 near mature redwoods.

Right: variation in soil color from surface to 60".

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-6"	Clay	Platy, compacted	Dry	Common roots (grass & redwood)	
	6-24"	Clay	Massive	Dry	Common roots to 1/2"	Common very small gravels
	24-28"	Clay		Very slightly moist	Common roots	Common very small gravels
	28-33"	Clay		Very dry	Common roots to 1/4"	Occasional redox
	33-40"	Clay		Very dry	Occasional small roots	
	40-46"	Clay		Slightly moist	Occasional roots	Occasional small gravels; occasional bright green mottles
	46-60"	Clay		Slightly moist	Occasional small roots	Occasional small gravels

Chemical Analyses

	7A	7B	7C
Depth of sample	6-12"	28-34"	52-58"
pH	6.8	7.9	8.0
ECe (mmhos/cm)	0.4	0.5	0.9
Sodium (meq/l)	2.0	1.7	1.7
Chloride (meq/l)	1.6	1.0	1.8
Boron (ppm)	0.4	0.5	0.3
SAR	2.2	1.3	0.9

Sampled June 10, 2010

Appendix 3
Site Evaluation

Soil Investigation #8
Mitchell Park

Location: 3800 Middlefield Road
East side of library
Description: Pit from tree spade-transplanted ash
Vegetation: Turf on surface

Site #8: soil pit created when ash was removed with a tree spade.

Soil pofile at edge of pit. Note roots.

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-6"	Clay	Compacted, platy	Dry	Common roots	Few gravels
	6-48"	Clay		Dry	Common large roots to >48" deep, diameter to 4"	Few small gravels
	48 to >60	Clay		Slighly moist	Few roots	Common very small gravels; occasional redox (relict)

Chemical Analyses

	8A
Depth of sample	6-20"
pH	7.8
ECe (mmhos/cm)	0.3
Sodium (meq/l)	1.3
Chloride (meq/l)	0.8
Boron (ppm)	0.3
SAR	1.2

Sampled June 10, 2010

Soil Investigation #9
Terman Park

Location:	695 Atrastradero
	Turf area on NW corner 20' from sweetgum
Description:	Soccer field
	Mapped as Pleasanton gravelly loam
Vegetation:	Turf moderately moist; sweetgum trees

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-8"	Clay	Compacted, platy	Slightly moist	Common roots; root mat; coarse roots to 1/4"	Top-dressed with coarse sand; common small gravels
	8-18"	Gravelly clay		Slightly moist	Common roots to 1/4"	Some faint redox; probably imported top soil
	18-22"	Gravelly clay		Dry	Common fine to coarse roots	Probably imported top soil
	22-40"	Gravelly clay		Dry	Common roots to 1"	Occasional faint redox
	40 to >60	Gravelly clay		Dry	Common coarse roots to depth	

Chemical Analyses

	9A	9B
Depth of sample	6-12"	20-40"
pH	7.0	7.0
ECe (mmhos/cm)	0.3	0.3
Sodium (meq/l)	1.2	1.3
Chloride (meq/l)	0.6	0.4
Boron (ppm)	0.2	0.2
SAR	1.3	1.5

Sampled June 10, 2010

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Appendix 3
Site Evaluation

Soil Investigation #10
Hewlett Packard

Location: 3000 Hanover Street

Description: Turf area west of volleyball court
Lower terrace; adjacent to mature redwod 20' to north

Vegetation: Turf slopes down to mulched redwoods and native oaks in area; diverse plant palette

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-8"	Compacted gravelly clay	Platy to 4" depth; angular blocky 4-8" depth	Very moist	Common roots	Gravels to 2"; +/- 50% gravels
	8-24"	Gravelly clay		Moist	Common roots	Gravels to 50%; scattered redox (faint)
	24-42"	Gravelly clay		Moist to depth	Occasional coarse roots (redwood); few fine roots	Gravels to 50%; scattered faint redox; occasional charcoal; refusal at 42" (rocks)

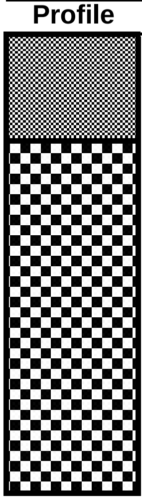
Chemical Analyses

	10A	10B
Depth of sample	4-8"	36-42"
pH	7.1	7.8
ECe (mmhos/cm)	0.5	0.03
Sodium (meq/l)	1.1	1.0
Chloride (meq/l)	1.2	1.0
Boron (ppm)	0.4	0.3
SAR	0.8	1.0

Sampled July 6, 2010

Appendix 3 **Site Evaluation** | **Soil Investigation #11**
Hewlett Packard

Location: 3000 Hanover Street
Between parking lots by basketball court
Description: Rocky soils; cut slope
Vegetation: Redwoods (tree tag 843), oleander hedge



Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-4"	Very gravelly clay	Compacted	Dry	Common roots	Gravels and cobbles to 3"; apparently porous soil with few upper profile constraints
	4-20"	Gravelly clay		Dry	Common coarse to fine roots (redwood) to 3/4" diameter	

Chemical Analyses

	11A
Depth of sample	4-8"
pH	6.4
ECe (mmhos/cm)	0.8
Sodium (meq/l)	2.4
Chloride (meq/l)	4.4
Boron (ppm)	0.4
SAR	1.6

Sampled July 6, 2010

Appendix 3
Site Evaluation

Soil Investigation #12
Tesla Motors

Location: 3500 Deer Creek Road
Description: Mulched organic surface; no irrigation
Original surface with California
live oaks
Vegetation: California live oak, English oak, Eucalyptus

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-4"	Gravelly clay or clay loam	Compacted, platy; porous, crumbly	Dry	Common fine to coarse roots	
	4-16"	Gravelly clay loam	Angular, blocky	Very dry	Few roots	Common gravels
	16-24"	Clay		Very dry	Few roots	Common gravels

Chemical Analyses

	12A	12B
Depth of sample	4-8"	20-24"
pH	6.6	6.8
ECe (mmhos/cm)	0.4	0.2
Sodium (meq/l)	1.2	1.1
Chloride (meq/l)	1.6	1.0
Boron (ppm)	0.4	0.4
SAR	1.0	1.5

Sampled July 6, 2010

Location: 3500 Deer Creek Road
Description: Filled surface at edge of parking lot; slipoff slope at west side; numerous squirrel burrows/mounds
Vegetation: California live oaks, sycamore and eucalyptus with dry duff

Profile	Depth	Texture	Structure	Moisture	Roots	Comments
	0-6"	Clay loam		Dry	Common roots	Common gravels
	6-16"	Clay loam		Dry to slightly moist	Common fine to coarse roots (oak)	Common gravels
	16-22"	Clay loam		Moist	Common roots to 2" (oak)	Common gravels

Chemical Analyses

	13A	13B
Depth of sample	6-12"	16-22"
pH	7.9	6.9
ECe (mmhos/cm)	0.4	0.5
Sodium (meq/l)	1.5	1.0
Chloride (meq/l)	1.0	1.2
Boron (ppm)	0.3	0.2
SAR	1.3	0.6
Lime (% $CaCO_3$)	3.6	

Sampled July 6, 2010

Appendix 4

PERRY LABORATORY
HORTICULTURAL ADVISING AND TESTING

424 AIRPORT BOULEVARD
WATSONVILLE, CA 95076
Telephone 831/722-7606
Fax 831/722-5053

HortScience, Inc.
2150 Rheem Drive, Suite A
Pleasanton, CA 94588

June 18, 2010

Chemical analyses on samples received: June 15, 2010

Sample Identification	pH	Electrical Conductivity dS/m	SP Saturation Percentage	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Chloride (Cl)	Boron (B)	SAR Sodium Adsorption Ratio	ESP Exchangeable Sodium Percentage
				milliequivalents per liter in extract				ppm in extract		
General Guidelines-Ornamental Plants	6.5-7.2	1.0-3.0		>3.0	>2.0	<3.0	<3.0	<1.0	<8.0	<9.0
Job 3752-01										
1A, 6-12"	6.7	0.6	49	3.6	1.2	1.0	0.6	0.2	0.7	0.8
1B, 18-24"	6.3	0.3	31	1.2	0.7	1.5	1.4	0.3	1.5	1.7
1C, 2.5-3'	6.8	0.3	60	1.0	0.7	1.1	0.8	0.2	1.2	1.3
2A, 6-12"	7.1	0.3	32	1.4	0.7	1.2	0.6	0.2	1.2	1.3
2A, 14-20"	7.4	0.2	63	0.3	0.4	1.1	0.6	0.1	1.9	2.1
3A, 6-12"	5.8	0.2	48	0.5	0.7	1.0	0.6	0.4	1.3	1.5
3B, 14-20"	6.1	0.2	40	0.2	0.5	1.0	0.8	0.3	1.7	1.9
4A, 6-12"	5.5	0.4	36	1.7	0.8	1.8	1.8	0.4	1.6	1.8
5A, 6-12"	8.0	0.4	46	1.2	0.7	1.8	0.8	0.3	1.9	2.1
5B, 12-24"	7.6	0.6	43	1.6	1.3	2.5	1.0	0.1	2.1	2.3
6A, 6-12"	7.4	0.5	48	2.1	1.0	1.7	0.8	0.1	1.4	1.6
6B, 14-18"	7.5	0.7	53	2.5	2.1	2.2	1.6	0.2	1.5	1.7
6C, 18-26"	7.5	0.7	51	2.9	2.3	2.3	1.4	0.2	1.4	1.6
7A, 6-12"	6.8	0.4	54	0.6	1.0	2.0	1.6	0.4	2.2	2.5
7B, 28-34"	7.9	0.5	48	1.1	2.2	1.7	1.0	0.5	1.3	1.5
7C, 52-58"	8.0	0.9	39	2.8	4.8	1.7	1.8	0.3	0.9	1.0
8A, 6-20"	7.8	0.3	60	1.4	1.1	1.3	0.8	0.3	1.2	1.3
9A, 6-12"	7.0	0.3	46	0.8	0.8	1.2	0.6	0.2	1.3	1.5
9B, 20-40"	7.0	0.3	36	0.7	0.8	1.3	0.4	0.2	1.5	1.7

Respectfully submitted,

Clifford B. Low, M.S.

Appendix 4

PERRY LABORATORY

HORTICULTURAL ADVISING AND TESTING

424 AIRPORT BOULEVARD
WATSONVILLE, CA 95076
Telephone 831/722-7606
Fax 831/722-5053

HortScience, Inc.
2150 Rheem Drive, Suite A
Pleasanton, CA 94588

June 18, 2010

Chemical analyses on samples received: June 15, 2010

Sample Identification	Mechanical Analyses, % by weight, USDA Classifications			
Job 3752-01	Sand	Silt	Clay	Texture
1A, 6-12"	54	32	14	sandy loam
1B, 18-24"	46	36	18	loam
1C, 2.5-3'	34	42	24	loam
2A, 6-12"	72	16	12	sandy loam
2A, 14-20"	32	44	24	loam
3A, 6-12"	38	32	30	clay loam
3B, 14-20"	58	28	14	sandy loam
4A, 6-12"	60	26	14	sandy loam
5A, 6-12"	54	20	16	sandy loam
5B, 12-24"	58	28	14	sandy loam
6A, 6-12"	56	28	16	sandy loam
6B, 14-18"	52	34	14	loam
6C, 18-26"	46	34	20	loam
7A, 6-12"	56	30	14	sandy loam
7B, 28-34"	52	46	2	sandy loam
7C, 52-58"	58	28	14	sandy loam
8A, 6-20"	30	62	8	silt loam
9A, 6-12"	48	32	20	loam
9B, 20-40"	54	34	12	sandy loam

Respectfully submitted,

Clifford B. Low, M.S.

Appendix 4

PERRY LABORATORY

HORTICULTURAL ADVISING AND TESTING

424 AIRPORT BOULEVARD
WATSONVILLE, CA 95076
Telephone 831/722-7606
Fax 831/722-5053

SOIL-PLANT-WATER-ANALYSIS

HortScience, Inc.
2150 Rheem Drive, Suite A
Pleasanton, CA 94588

July 16, 2010

Chemical analyses on samples received: July 9, 2010

Sample Identification	pH	Electrical Conductivity dS/m	SP Saturation Percentage	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Chloride (Cl)	Boron (B)	SAR Sodium Adsorption Ratio	ESP Exchangeable Sodium Percentage	Lime Content
				milliequivalents per liter in extract				ppm in extract			% by wt.
General Guidelines-Ornamental Plants	6.5-7.2	1.0-3.0		>3.0	>2.0	<3.0	<3.0	<1.0	<8.0	<9.0	<3.0
10A, 4-8"	7.1	0.5	41	2.9	1.2	1.1	1.2	0.4	0.8	0.9	
10B, 36-42"	7.8	0.03	37	1.4	0.8	1	1	0.3	1	1.1	
11A, 4-8"	6.4	0.8	46	3.3	1.6	2.4	4.4	0.4	1.6	1.8	
12A, 4-8"	6.6	0.4	47	2.3	1.0	1.2	1.6	0.4	1.0	1.1	
12B, 20-24"	6.8	0.2	39	0.4	0.7	1.1	1	0.4	1.5	1.7	
13A, 6-12"	7.9	0.4	43	1.6	0.9	1.5	1.0	0.3	1.3	1.5	3.6
13B, 16-22"	6.9	0.5	46	2.1	3	1	1.2	0.2	0.6	0.7	

Respectfully submitted,

Clifford B. Low, M.S.

Appendix 4

PERRY LABORATORY
HORTICULTURAL ADVISING AND TESTING

424 AIRPORT BOULEVARD
WATSONVILLE, CA 95076
Telephone 831/722-7606
Fax 831/722-5053

SOIL-PLANT-WATER-ANALYSIS

HortScience, Inc.
2150 Rheem Drive, Suite A
Pleasanton, CA 94588

July 16, 2010

Chemical analyses on samples received: July 9, 2010

Sample Identification	Mechanical Analyses, % by weight, USDA Classifications			
	Sand	Silt	Clay	Texture
10A, 4-8"	50	30	20	loam
10B, 36-42"	54	24	22	sandy clay loam
11A, 4-8"	44	48	8	loam
12A, 4-8"	58	26	16	sandy loam
12B, 20-24"	58	34	8	sandy loam
13A, 6-12"	54	28	18	sandy loam
13B, 16-22"	38	32	30	clay loam

Respectfully submitted,

Clifford B. Low, M.S.

Scientific Name	Common Name	Salt Tolerance	Frequency common, several, few	Condition good, fair, poor
Abelia x grandiflora	Glossy abelia	moderate	several	good
Acer palmatum	Japanese maple	low	few	fair
Agapanthus africanus cultivars	Lily-of-the-Nile	low	several	good
Arbutus unedo	Strawberry tree	moderate	several	fair
Betula pendula	European white birch	low	several	good
Camellia japonica	Camellia	moderate	several	good
Cedrus atlantica	Atlas cedar	moderate	few	good
Cedrus deodara	Deodar cedar	moderate	several	good
Clivia miniata	Kaffir lily	low	few	fair
Clytostoma callistegioides	Violet trumpet vine	low	several	good
Cyperus papyrus	Papyrus	moderate	several	good
Dietes iridiodes	Fortnight lily	high	few	good
Equiseteum hyenale	Horsetail	moderate	common	good
Eucalyptus globulus	Blue gum	high	several	good
Fraxinus augustifolia 'Raywood'	Raywood ash	moderate	several	fair
Fraxinus uhdei	Evergreen ash	moderate	several	good
Hedera canariensis	Algerian ivy	high	several	good
Hedera helix	English ivy	high	common	good
Hydrangea macrophylla 'Lacecap'	Lacecap hydrangea	moderate	few	good
Impatiens walleriana	Busy Lizzie	low	several	good
Juncus effusus	Soft rush	unknown	common	good
Ligustrum japonicum	Texas privet	moderate	several	good
Liquidambar stryraciflua	Sweet gum	low	common	good
Liriope muscari 'Variegata'	Big blue lily turf	moderate	several	good
Loropetalum chinense 'Razzleberry'	Loropetalum	low	common	good
Magnolia grandiflora	Southern magnolia	low	few	poor
Michelia doltsopa	Michelia	low	several	good
Nandina domestica	Heavenly bamboo	low	few	fair
Nerium oleander	Oleander	high	common	good
Nymphaea	Water lily	low	several	good
Panicum virgatum	Switch grass	high	several	good
Penstemon cultivars	Penstemon	moderate	several	good
Photinia x fraseri	Photinia	moderate	common	good
Pinus canariensis	Canary Island pine	high	several	good-poor
Pittosporum tobira 'Wheeler's Dwarf'	Wheeler's tobira	high	few	fair
Polystichum munitum	Western sword fern	low	few	fair
Prunus cerasifera 'Atropurpurea'	Purple-leaf plum	moderate	several	good
Prunus laurocerasus 'Zabeliana'	English laurel	moderate	several	good
Prunus x yedoensis 'Akebono'	Flowering cherry	low	few	good
Pyrus kawakamii	Evergreen pear	high	few	poor
Rhaphiolepis indica	Indian hawthorn	high	common	good
Rhododendron cultivars	Azalea	low	few	fair
Rhododendron cultivars	Rhododendron	low	few	good

Landscape Plant Inventory
Clocktower

Scientific Name	Common Name	Salt Tolerance	**Frequency** common, several, few	**Condition** good, fair, poor
Rosa cultivars	Groundcover rose	moderate	several	good
Salix babylonica	Weeping willow	moderate	few	good
Sarcococca hookeriana humilis	Sweet box	low	several	good
Sequoia sempervirens 'Soquel'	Coast redwood	low	several	good-fair
Trachelospermum jasminoides	Star jasmine	moderate	several	good
Typha angustifolia	Cattail	high	several	good
Viburnum suspensum	Sandankwa viburnum	high	common	good
Xylosma congestum	Xylosma	moderate	several	good

Scientific Name	Common Name	Salt Tolerance	Frequency common, several, few	Condition good, fair, poor
Acanthus mollis	Bear's breech	low	few	good
Acer palmatum	Japanese maple	low	few	good
Acer rubrum	Red maple	low	few	good
Agapanthus africanus cultivars	Lily-of-the-Nile	low	several	good
Artemesia californica 'Montara'	Artemesia	moderate	few	good
Berberis thunbergii 'Crimson Pygmy'	Japanese barberry	low	several	good
Calamagrostis x acutiflora 'Karl Foerster'	Reed grass	high	several	good
Callistemon citrinus	Lemon bottlebrush	high	several	fair
Camellia japonica	Camellia	moderate	several	fair-good
Carpenteria californica	Bush anemone	unknown	few	good
Ceanothus cultivars	Wild lilac	high	several	good
Ceratonia siliqua	Carob	moderate	few	good
Citrus x *limon*	Lemon	low	several	good
Cotoneaster dammeri	Bearberry cotoneaster	moderate	several	good
Cyperus alternifolius 'Gracilis'	Dwarf umbrella plant	moderate	several	good
Echium cadicans	Echium	high	few	good
Erigeron karvinskianus	Mexican daisy	high	several	good
Eucalyptus globulus	Blue gum	high	several	good
Eucalyptus viminalis	Manna gum	high	several	good
Euphorbia characias wulfenii	Euphorbia	high	several	good
Festuca rubra	Red fescue	moderate	common	good
Ficus pumila	Creeping fig	high	several	good
Fragaria chiloensis	Ornamental strawberry	low	several	good
Gaura lindheimeri	Gaura	moderate	several	good
Geranium cultivars	Cranesbill	moderate	several	good
Ginkgo biloba	Maidenhair tree	moderate	few	good
Grevillea 'Noellii'	Grevillea	moderate	several	good
Hedera helix	English Ivy	high	few	good
Hemerocallis hybrids	Daylilly	high	few	good
Heuchera sanguinea	Coral bells	moderate	several	good
Hypericum calycinum	Creeping St. Johnswort	moderate	several	good
Iberis sempervirens	Evergreen candytuft	moderate	several	good
Impatiens walleriana	Busy Lizzie	low	several	good
Iris douglasiana	Pacific coast iris	moderate	several	good
Juncus effusus '	Soft rush	unknown	common	good
Juniperus chinensis cvs.	Juniper	high	common	good
Lampranthus spectablis	Ice plant	high	common	fair-good
Lantana montevidensis	Lantana	high	several	fair
Lavandula angustifolia	English lavender	high	common	good
Lavatera maritima	Tree mallow	high	several	fair

Scientific Name	**Common Name**	**Salt Tolerance**	**Frequency** common, several, few	**Condition** good, fair, poor
Leucadendron tinctum	Leucadendron	unknown	several	good
Liriope muscari 'Variegata'	Big blue lily turf	moderate	several	good
Lonicera japonica 'Halliana'	Hall's honeysuckle	moderate	few	fair
Maytenus boaria	Mayten	high	few	fair
Michelia doltsopa	Michelia	low	few	good
Miscanthus sinensis 'Gracillimus'	Maiden grass	high	common	good
Muhlenbergia rigens	Deer grass	high	common	good
Myoporum parvifolium 'Prostratum'	Myoporum	high	common	good
Nasella tenuissima	Mexican feather grass	moderate	common	good
Ophiopogon japonicus	Mondo grass	low	common	fair-good
Passiflora jamesonii	Passion flower	low	few	good
Pennisetum orientale	Oriental fountain grass	high	common	good
Phormium hybrids	Phormium	high	several	good
Pinus canariensis	Canary Island pine	high	several	good
Pinus pinea	Italian stone pine	high	few	good
Pistacia chinensis	Chinese pistache	moderate	several	fair
Pittosporum tobira 'Variegata'	Variegated tobira	high	several	good
Pittosporum undulatum	Victorian box	moderate	several	good
Platanus x acerifolia	London plane	moderate	several	good
Polystichum munitum	Western sword fern	low	few	good
Populus fremontii	Fremont cottonwood	moderate	several	good
Prunus carolinia 'Bright 'N Tight	Carolina laurel cherry	moderate	few	good
Quercus agrifolia	Coast live oak	high	several	fair-good
Rhamnus californica 'Eve Case'	California coffeeberry	low	several	good
Rhododendron spp.	Azalea	low	few	fair
Robinia x ambigua 'Purple Robe'	Locust	moderate	several	good
Rosmarinus officinalis	Rosemary	high	several	good
Salvia farinacea	Texas violet	high	several	good
Schinus molle	California pepper	high	several	good
Senecio mandraliscae	Senecio	high	several	good
Sequoia sempervirens 'Soquel'	Coast redwood	low	common	good
Trachelospermum jasminoides	Star jasmine	moderate	common	good
Vinca minor	Dwarf periwinkle	moderate	several	good

Scientific Name	Common Name	Salt Tolerance	Frequency common, several, few	Condition good, fair, poor
Acer rubrum	Red maple	low	few	good
Aesculus x *carnea*	Red horsechestnut	low	few	good
Agapanthus africanus	Lily-of-the-Nile	low	several	good
Albizia julibrissin	Silk tree	low	few	good
Betula pendula	European white birch	low	several	good
Calendula officinalis	Calendula	moderate	few	good
Calodendrum capense	Cape chestnut	moderate	several	good
Canna	Canna	unknown	several	good
Casuarina equisetifolia	Horsetail tree	high	few	good
Ceanothus cultivars	Wild lilac	high	few	good
Cedrus atlantica 'Glauca'	Atlas cedar	moderate	few	good
Cedrus deodara	Deodar cedar	moderate	several	good
Celtis occidentalis	Common hackberry	low	few	good
Ceratonia siliqua	Carob	moderate	several	good - fair
Cinnamomum camphora	Camphor	moderate	several	good
Citrus x limon	Lemon	low	few	good
Cosmos bipinnatus	Cosmos	moderate	few	fair
Dietes iridioides	Fortnight lily	high	several	fair
Dodonea viscosa	Hopseed bush	moderate	few	fair
Eryobotrya japonica	Loquat	moderate	few	good
Escallonia rubra	Pink escallonia	moderate	several	good
Eucalyptus polyanthemos	Silver dollar gum	high	common	good
Eucalyptus viminalis	Manna gum	high	common	good
Fraxinus angustifolia 'Raywood'	Raywood ash	moderate	few	good
Fraxinus pennsylvanica 'Cimmzam'	Cimmaron ash	moderate	few	good
Fraxinus uhedi	Evergreen ash	moderate	several	good
Geranium cultivars	Cranesbill	moderate	few	good
Ginkgo biloba	Maidenhair tree	moderate	several	good
Hebe 'Coed'	Hebe	high	several	good
Hedera canariensis	Algerian ivy	high	common	good
Hedera helix	English ivy	high	several	fair
Hemerocallis hybrids	Daylilly	high	few	good
Iris douglasiana	Pacific coast iris	high	few	fair
Juniperus chinensis 'Torulosa'	Hollywood juniper	moderate	few	good
Lantana montevidensis	Lantana	high	few	fair
Ligustrum lucidum	Glossy privet	moderate	few	good
Lonicera japonica 'Halliana'	Hall's honeysuckle	high	few	good
Malus floribunda	Flowering crabapple	low	few	fair
Maytenus boaria	Mayten	high	several	fair-good

Scientific Name	Common Name	Salt Tolerance	**Frequency** common, several, few	**Condition** good, fair, poor
Morus alba	Mulberry	moderate	several	good
Oenethera speciosa	Mexican evening primrose	high	several	good
Olea europaea	Olive	high	few	good
Pennisetum orientale	Oriental fountain grass	high	few	good
Phormium hybrids	Flax	high	several	good
Pinus canariensis	Canary Island pine	high	several	good
Pinus pinea	Italian stone pine	high	several	fair
Pinus radiata	Monterey pine	high	common	good
Pistacia chinensis	Chinese pistache	moderate	few	good
Pittosporum tobira	Tobira	high	several	good
Pittosporum undulatum	Victorian box	moderate	few	good
Platanus x acerifolia 'Bloodgood'	London plane	moderate	few	good
Populus nigra 'Italica'	Lombardy poplar	moderate	few	fair
Prunus ilicifolia lyonii	Catalina cherry	moderate	few	good
Prunus laurocerasus	English laurel	moderate	several	good
Prunus serrulata	Flowering cherry	low	few	good
Pyrus calleryana	Callery pear	high	few	good
Quercus coccinea	Scarlet oak	moderate	few	good
Quercus ilex	Holly oak	moderate	several	good
Quercus lobata	Valley oak	moderate	several	good
Quercus palustris	Pin oak	low	few	good
Quercus suber	Cork oak	moderate	several	good
Rosa cvs	Groundcover rose	moderate	several	good
Rosmarinus officinalis	Rosemary	high	few	good
Salix babylonica	Weeping willow	moderate	few	good
Salvia greggii 'Lipstick'	Lipstick salvia	high	several	good
Sequoia sempervirens 'Soquel'	Coast redwood	low	several	good
Syringa vulgaris	Common lilac	high	few	good
Taxus baccata	English yew	low	few	fair-poor
Tilia tomentosa 'Sterling Silver'	Silver linden	low	few	good
Trachelospermum jasminoides	Star jasmine	moderate	several	good
Ulmus parvifolia	Chinese evergreen elm	moderate	several	good
Washingtonia filifera	California fan palm	high	few	good
Wisteria sinensis	Chinese wisteria	low	several	good
Xylosma congestum	Xylosma	moderate	several	good

Landscape Plant Inventory
Terman Park and School

Scientific Name	Common Name	Salt Tolerance	**Frequency** common, several, few	**Condition** good, fair, poor
Albizia julibrissin	Silk tree	low	few	fair
Alnus rhombifolia	White alder	low	few	good
Arbutus unedo	Strawberry tree	moderate	few	fair
Arctostaphylos 'Howard McMinn'	Howard McMinn manzanit	high	several	fair
Betula pendula	European white birch	low	few	good
Buddleja davidii	Butterfly bush	low	few	fair
Calocedrus decurrens	Incense cedar	low	few	good
Camellia japonica	Camellia	moderate	few	fair
Cotoneaster lacteus	Cotoneaster	moderate	few	good
Crataegus laevigata	English hawthorn	moderate	few	fair
Erysimim hybrids	Wallflower	unknown	few	fair
Escallonia rubra	Escallonia	moderate	common	good
Euonymus japonica	Evergreen euonymus	high	common	good
Euryops pectinatus	Euryops	low	several	fair
Fraxinus angustifolia 'Raywood'	Raywood ash	moderate	few	good
Hedera helix	English ivy	high	common	good
Heteromeles arbutifolia	Toyon	high	common	good
Hibiscus rosa-sinensis	Chinese hibiscus	high	few	
Ligustrum lucidum	Glossy privet	moderate	common	good
Liquidambar stryraciflua	Sweet gum	low	few	good
Malus floribunda	Flowering crabapple	low	few	fair
Myrica californica	Pacific wax myrtle	high	few	fair
Nerium oleander	Oleander	high	several	good
Photinia x fraseri	Photinia	moderate	common	fair
Pinus radiata	Monterey pine	high	common	good
Prunus cerasifera 'Autropurpurea'	Purple-leaf plum	moderate	few	good
Prunus laurocerasus	English laurel	moderate	few	good
Pyracantha coccinea	Firethorn	high	common	good
Quercus agrifolia	Coast live oak	high	common	good
Rhaphiolepis indica	Indian hawthorn	high	several	good
Rubus armeniacus	Himalayan blackberry	high	common	good
Schinus terebinthifolius	Brazilian pepper	high	few	good
Sequoia sempervirens 'Soquel'	Coast redwood	low	few	fair
Ulmus parvifolia	Chinese evergreen elm	moderate	few	good
Vinca minor	Dwarf periwinkle	moderate	few	poor
Zelkova serrata	Sawleaf zelkova	moderate	few	good

Scientific Name	Common Name	Salt Tolerance	Frequency common, several, few	Condition good, fair, poor
Acer platanoides	Norway maple	moderate	common	fair
Aeonium sp.	Aeonium	high	several	good
Alchemilla mollis	Lady's mantle	moderate	few	poor to fair
Aloe striata	Coral aloe	high	few	good
Arctostaphylos 'Howard McMinn'	Howard McMinn manzanita	high	few	good
Arctostaphylos 'Pacific Mist'	Pacific Mist manzanita	high	few	good
Berberis thungergii 'Crimson Pygmy'	Red-leaf Japanese barberry	low	common	good
Callistemon viminalis	Weeping bottlebrush	high	several	good
Canna cultivar	Canna	low	common	good
Caryopteris x clandonensis	Blue mist	high	common	fair
Cercidiphyllum japonicum	Katsura tree	moderate	several	good
Cercis occidentalis	Western redbud	moderate	few	good
Dicksonia antarctica	Tasmanian tree fern	unknown	few	good
Dietes iridiodes	Fortnight lily	high	several	good
Digitalis purpurea	Foxglove	moderate	several	fair
Festuca calfornica	California fescue	moderate	common	good
Festuca rubra	Red fescue	moderate	few	good
Fragaria chiloensis	Ornamental strawberry	low	common	good
Helectotrichon sempervirens	Blue oat grass	high	several	good
Helleborus argutifolius	Corsican hellebore	moderate	several	fair
Hemerocallis hybrids	Daylily	high	several	good
Hesperaloe parviflora	Red yucca	moderate	several	good
Heuchera maxima	Island alum root	moderate	few	good
Imperata cylindrica 'Rubra'	Japanese blood grass	unknown	several	good
Iris cultivar	Variegated iris	moderate	several	good
Juncus patens	California grey rush	unknown	common	good
Kniphofia citrina	Red-hot poker	moderate	few	good to poor
Lagerstroemia indica	Crape myrtle	low	several	good
Lavatera maritima	Tree mallow	high	several	poor to fair
Leonotis leonurus	Lion's tail	moderate	several	good to fair
Ligustrum japonicum	Privet	moderate	several	good
Liriope muscari	Big blue lily turf	moderate	several	fair to good
Liriope spicata	Creeping lily turf	moderate	several	fair
Lophostemon confertus	Brisbane box	moderate	several	fair
Melaleuca quinquenervia	Cajeput tree	moderate	several	good
Muhlenbergia rigens	Deer grass	high	several	good
Olea europaea	Olive	high	several	fair
Phormium hybrids	Flax hybrids	high	few	fair
Pinus canariensis	Canary Island pine	high	few	fair

Scientific Name	Common Name	Salt Tolerance	**Frequency** common, several, few	**Condition** good, fair, poor
Pinus radiata	Monterey pine	high	several	fair
Pistacia chinensis	Chinese pistacia	moderate	few	good
Polystictum munitum	Western sword fern	low	few	good
Prunus caroliniana	Carolina laurel cherry	moderate	few	poor to fair
Prunus laurocerasus ' Zabeliana'	Zabeliana English laurel	moderate	several	good
Quercus agrifolia	Coast live oak	high	several	good
Quercus rubra	Red oak	high	several	good
Quercus virginiana	Southern live oak	high	few	good
Rhamnus californica 'Eve Chase'	California coffeeberry	high	few	fair
Teucrium fruticans	Bush germander	moderate	common	good
Xylosma congestum	Shiny xylosma	moderate	few	good

Scientific Name	Common Name	Salt Tolerance	Frequency common, several, few	Condition good, fair, poor
Acer palmatum	Japanese maple	low	few	good
Agapanthus africanus	Lily-of-the-Nile	low	common	fair
Arbutus unedo	Strawberry tree	moderate	few	good
Arctostaphylos uva-ursi	Bearberry	high	several	good
Armeria maritima	Thrift	high	several	fair
Aspidistra elatior	Cast-iron plant	moderate	several	good
Baccharis pilularis	Dwarf coyote brush	high	common	good
Calamagrostis x acutiflora 'Karl Foerster'	Reed grass	high	several	good
Calluna vulgaris	Scotch heather	low	several	fair
Camellia japonica	Camellia	moderate	several	good
Carex morowii expallida	Variegated Japanese sed	unknown	several	good
Ceanothus cultivars	Wild lilac	high	several	good
Cercis occidentalis	Western redbud	moderate	several	good
Coleonema pulchrum 'Sunset Gold'	Pink breath of heaven	high	several	good
Cotinus coggygria	Smoke tree	moderate	several	good
Cotoneaster dammeri 'Lowfast'	Bearberry cotoneaster	moderate	common	good
Cotoneaster lacteus	Parney's cotoneaster	high	common	good
Dicksonia antarctica	Tasmanian tree fern	unknown	several	good
Dietes irioides	Fortnight lily	high	common	good
Eleagnus pungens 'Maculata'	Golden eleagnus	moderate	several	good
Eucalyptus polyanthemos	Silver dollar gum	high	several	good
Euonymus fortunei cultivars	Winter creeper	high	several	good
Fagus sylvatica 'Autropunicea'	Copper beech	low	few	good
Festuca californica	California fescue	moderate	several	good
Fraxinus augustifolia 'Raywood'	Raywood ash	moderate	few	good
Galvezia speciosa	Island bush snapdragon	high	common	fair
Geijera parviflora	Australian willow	moderate	few	fair
Geranium cultivars	Cranesbill	unknown	common	good
Ginkgo biloba	Maidenhair tree	moderate	common	good-fair
Hedera helix	English ivy	high	common	good
Helleborus niger	Christmas rose	moderate	several	good
Hemerocallis hybrids	Daylily	high	common	good
Hydrangea macrophylla	Hydrangea	moderate	few	good
Juncus effusus cultivars	Soft rush	unknown	few	good
Kniphofia uvaria	Red-hot poker	moderate	common	good-fair
Lagerstroemia indica	Crape myrtle	low	several	good
Lantana montevidensis	Lantana	high	few	fair
Leptospermum scoparium	New Zealand tea tree	high	several	good
Ligustrum lucidum	Glossy privet	moderate	few	good
Liquidambar stryraciflua	Sweet gum	low	common	good
Liriodendron tulipifera	Tulip tree	low	common	good
Magnolia grandiflora	Southern magnolia	low	several	good
Mahonia aquifolium	Oregon grape	low	several	good

Scientific Name	Common Name	Salt Tolerance	**Frequency** common, several, few	**Condition** good, fair, poor
Malus floribunda	Flowering crabapple	low	few	good
Nandina domestica	Heavenly bamboo	low	few	good
Nasella tenuissima	Mexican feather grass	moderate	few	good
Nerium oleander	Oleander	high	common	good
Olea europaea	Olive	high	few	good
Osteospermum fruticosum	Trailing African daisy	moderate	several	fair
Parthenocissus tricuspidata	Boston ivy	low	several	good
Pennisetum setaceum 'Cupreum'	Red fountain grass	high	few	good
Phormium hybrids	Flax	high	common	good
Phormium tenax	New Zealand fax	high	few	good
Photinia x fraseri	Photinia	moderate	several	good
Pinus canariensis	Canary Island pine	high	several	good
Pinus pinea	Italian stone pine	high	several	good
Pistacia chinensis	Chinese pistache	moderate	common	good
Pittosporum tobira	Tobira	high	several	good
Pittosporum tobira 'Wheeler's Dwarf'	Wheeler's tobira	high	common	good
Podocarpus macrophyllus	Yew pine	moderate	several	good
Polystichum munitum	Western sword fern	low	several	fair
Prunus cerasifera 'Autropurpurea'	Purple-leaf plum	moderate	few	good
Pyrus calleryana	Callery pear	high	several	good
Quercus ilex	Holly oak	moderate	common	good-fair
Quercus lobata	Valley oak	moderate	common	fair
Quercus macrocarpa	Burr oak	high	few	good
Quercus rubra	Red oak	high	several	good
Rhaphiolepis indica	Indian hawthorn	high	common	good
Robinia x ambigua 'Purple Robe'	Locust	high	few	good-fair
Rosa cultivars	Groundcover rose	moderate	common	good-fair
Salvia chiapensis	Chiapas sage	moderate	several	good
Salvia leucantha	Mexican bush sage	high	several	good
Schefflera actinophylla	Queensland umbrell tree	moderate	few	good
Schefflera elagantissima	Thread leaf false aralia	moderate	few	good
Schinus terebinthifolius	Brazilian pepper	high	few	good
Sequoia sempervirens 'Soquel'	Coast redwood	low	common	good-fair
Sesleria caeruela	Blue moor grass	unknown	several	good
Strelitizia reginae	Bird of Paradise	high	few	fair
Tibochina urvilleana	Princess flower	low	few	fair
Trachelospermum jasminoides	Star jasmine	moderate	common	good
Tradescantia virginiana	Spiderwort	low	several	good
Ulmus parvifolia	Chinese evergreen elm	moderate	common	good
Verbena peruviana	Verbena	low	few	fair
Zauschneria californica	California fuschia	high	few	good

Appendix 5
Site Evaluation

Landscape Plant Inventory
Tesla Motors

Scientific Name	Common Name	Salt Tolerance	**Frequency** common, several, few	**Condition** good, fair, poor
Arctostaphylos uva-ursi	Bearberry manzanita	high	common	good-fair
Baccharis pilularis	Dwarf coyote brush	high	common	good-fair
Berberis thungergii 'Atropurpurea'	Red-leaf Japanese barber	low	several	good
Campsis radicans	Common trumpet creeper	moderate	several	fair
Casurina stricta	Coast beefwood	high	few	fair
Cercis occidentalis	Western redbud	moderate	several	fair
Correa pulchella	Australian fuchsia	moderate	few	good
Cotoneaster lacteus	Parney's cotoneaster	high	several	good
Dietes iridiodes	Fortnight lily	high	common	good
Eucalyptus leucoxylon 'Rosea'	White ironbark	high	few	good
Eucalyptus viminalis	Manna gum	high	few	good-fair
Hedera helix	English ivy	high	common	good
Heteromeles arbutifolia	Toyon	high	common	good
Hypericum calycinum	Creeping St. Johnswort	moderate	several	good-fair
Lagerstroemia indica	Crape myrtle	low	common	good
Lantana hybrids	Lantana	high	several	fair
Liriope muscari 'Variegata'	Big blue lily turf	moderate	several	good
Lonicera japonica 'Halliana'	Hall's honeysuckle	moderate	several	good
Melaleuca quinquenervia	Cajeput tree	moderate	several	good
Nandina domestica	Heavenly bamboo	low	few	good
Nasella tenuissima	Mexican feather grass	moderate	several	good
Nerium oleander 'Petite Pink'	Petite pink oleander	high	common	good
Parthenocissus tricuspidata	Boston ivy	low	several	good
Pennisetum alopecuriodes	Perennial fountain grass	high	several	good
Pinus canariensis	Canary island pine	high	several	good
Pistacia chinensis	Chinese pistache	moderate	common	good
Platanus x acerfolia	London plane	moderate	several	good
Plumbago auriculata	Cape plumbago	moderate	few	good
Prunus cerasifera 'Atropurpurea'	Purple-leaf plum	moderate	several	fair
Prunus serrulata	Flowering cherry	low	several	good
Pyracantha coccinea	Firethorn	high	several	good
Quercus agrifolia	Coast live oak	high	several	good-fair
Quercus ilex	Holly oak	moderate	common	good
Rhaphiolepis indica	Indian hawthorn	high	several	fair
Salvia leucantha	Mexican bush sage	high	few	good
Tipuana tipu	Tipu tree	moderate	several	good
Vitnex agnus-castus	Chaste tree	moderate	few good	
Xylosma congestum	Xylosma	moderate	few	fair

Appendix H – Tree Inventory of Seven Properties in the Stanford Research Park Area, Palo Alto Recycled Water Project, Phase 3

Tree Inventory of Seven Properties in the Stanford Research Park Area

Palo Alto Recycled Water Project
Phase 3

Prepared for:
RMC Water and Environment
222 Sutter Street, Suite 700
San Francisco, CA 94108

Prepared by:
HortScience, Inc.
325 Ray St.
Pleasanton, CA 94566

October 18, 2011

HORT SCIENCE

Tree Inventory of Seven Properties in the Stanford Research Park Area
Palo Alto Recycled Water Project, Phase 3
Palo Alto, CA

RMC Water and Environment is preparing an Environmental Impact Report for the Palo Alto Recycled Water Project, Phase 3. The project site is located in the Stanford Research Park area. HortScience, Inc. was asked to contribute to that effort by preparing an *Evaluation of Use of Recycled Water for Landscape Irrigation* (June 2011). That report described the results of landscape investigations conducted in June 2010 at seven properties in Palo Alto. At each property we investigated the soil characteristics, identified the plant taxa present and described the general condition and relative frequency of occurrence of the taxon in the landscape. In addition we estimated salt tolerance (high, moderate, low) of each species.

The City of Palo Alto has requested further information about the trees on each site. During October we performed the following:

1. At each of the seven sites (Fig. 1, Appendix), count the number of trees and identify by species.
2. Identify all Protected trees as defined in City of Palo Alto Municipal Code, Title 8, Trees & Vegetation which are: *Quercus agrifolia*, *Q. lobata* >11.5" trunk diameter at 4.5'; *Sequoia sempervirens* >18" trunk diameter at 4.5'.
3. Estimate the tolerance of each species to recycled water that will be supplied by the Palo Alto Regional Water Quality Control Plant (RWQCP), based on water quality data provided by the City of Palo Alto for Nov. 2008-Aug. 2010 (Table 1).

Table 1: Summary of RWQCP reclaimed water analyses for Nov. 2008 – August 2010

Parameter	Minimum	Maximum	Mean	Salinity Hazard[1]
TDS (mg/l)	870	1000	963	slight
EC_w (µmho/cm)	1518	1760	1656	moderate
Boron (B, mg/l)	0.31	Al	0.35	none
Chloride (Cl, mg/l)	308	384	339	moderate
Sodium (Na, mg/l)	170	240	211	moderate
Sodium adsorption ratio	5.3	5.9	5.0	none
Alkalinity	85	196	114	none
Nitrate (NO_3, mg/l)	19	26	23	none
pH	6.6	7.2	7.0	none

[1]Refer to *Evaluating Water Quality*, Appendix 1, in *Evaluation of Use of Recycled Water for Landscape Irrigation* (HortScience, Inc., June 2011).

Results of Study
The results of our tree inventory are detailed by site in the Appendix. A summary is provided in Table 2.

Table 2: Number of non-protected and protected trees at each site distributed by tolerance to PARWQCP recycled water.

Site	Number of taxa	Number of Trees							
		Not Protected				Protected			
		# Trees	High	Moderate	Low	# Trees	High	Moderate	Low
Theranos	15	95	58	28	9	4	4	0	0
VMware	25	626	246	188	192	114	7*	0	107
Clocktower	21	210	45	68	97	25	0	0	25
Mitchell Park	44	344	122	134	88	18	1	1	16
Terman Park	34	136	16	50	70	37	13	0	24
Hewlett Packard	46	770	230	194	346	141	7	40	94
Tesla Motors	26	428	308	97	23	107	81	26	0
Total, all sites	96+	2609	1025	759	825	446	113	67	266
% of trees, all sites		100%	39%	29%	32%	100%	25%	15%	60%

*Three trees were in decline with removal notices attached.
+Duplicates excluded

A total of 2609 non-protected trees, representing 96 taxa, were present at the seven sites. Approximately half of the non-protected trees were located at the Hewlett Packard (29%) and VM Ware (24%) sites.

A total of 446 protected trees, representing three taxa, were present at the seven sites. Eighty-two percent of the protected trees were located at the Hewlett Packard (32%), VM Water (26%) and Tesla Motors (24%) sites. Of the protected trees, 25% were coast live oak, 15% valley oak, and 60% coast redwood.

The current study differed from the 2010 study in tree taxa encountered at several locations: At the Hewlett Packard site, a parking area had been re-landscaped, adding over 100 trees. Similarly, a new section at VMware was landscaped. A mature weeping willow at Clocktower had died and removed from the inventory. The interior of the Terman Middle School campus was not accessible during the 2010 inventory; those trees were added in the current study. Finally, an unirrigated portion of Tesla property was excluded in the 2010 inventory; we added that area in the current study. Because of these changes, eight taxa were added.

The tolerance of each taxa to RWQCP recycled water that will be supplied by the Palo Alto Regional Water Quality Control Plant was estimated based on information available in the literature and our experience with the species in landscapes irrigated with recycled water and potable waters having similar salt concentrations. Each taxon was rated for salt tolerance (see tables in the Appendix). Of the 96 tree taxa present, 31% were rated as 'high', 34% as 'moderate', and 31% as 'low'.

Salt tolerance ratings for the total population of 2609 non-protected trees and 446 protected trees were as follows:

- 39% of the non-protected and 25% of the protected trees had 'high' salt tolerance. These plants are expected to maintain good appearance and health with appropriate irrigation with RWQCP recycled water.
- 29% of the non-protected and 15% of the protected trees had 'moderate' salt tolerance. These plants are expected to develop symptoms of salt stress when irrigated with current RWQCP recycled water, especially in poorly drained soils. These plants may show some damage, but appearance will likely be acceptable when viewed from several feet away. Regular and thorough leaching will be required to maintain these plants.
- 32% of the non-protected and 60% of the protected trees had low salt tolerance. Foliage damage to these plants is likely to be obvious and degrade plant appearance. It is unlikely that leaching treatments using current recycled water would be adequate to prevent plant damage.

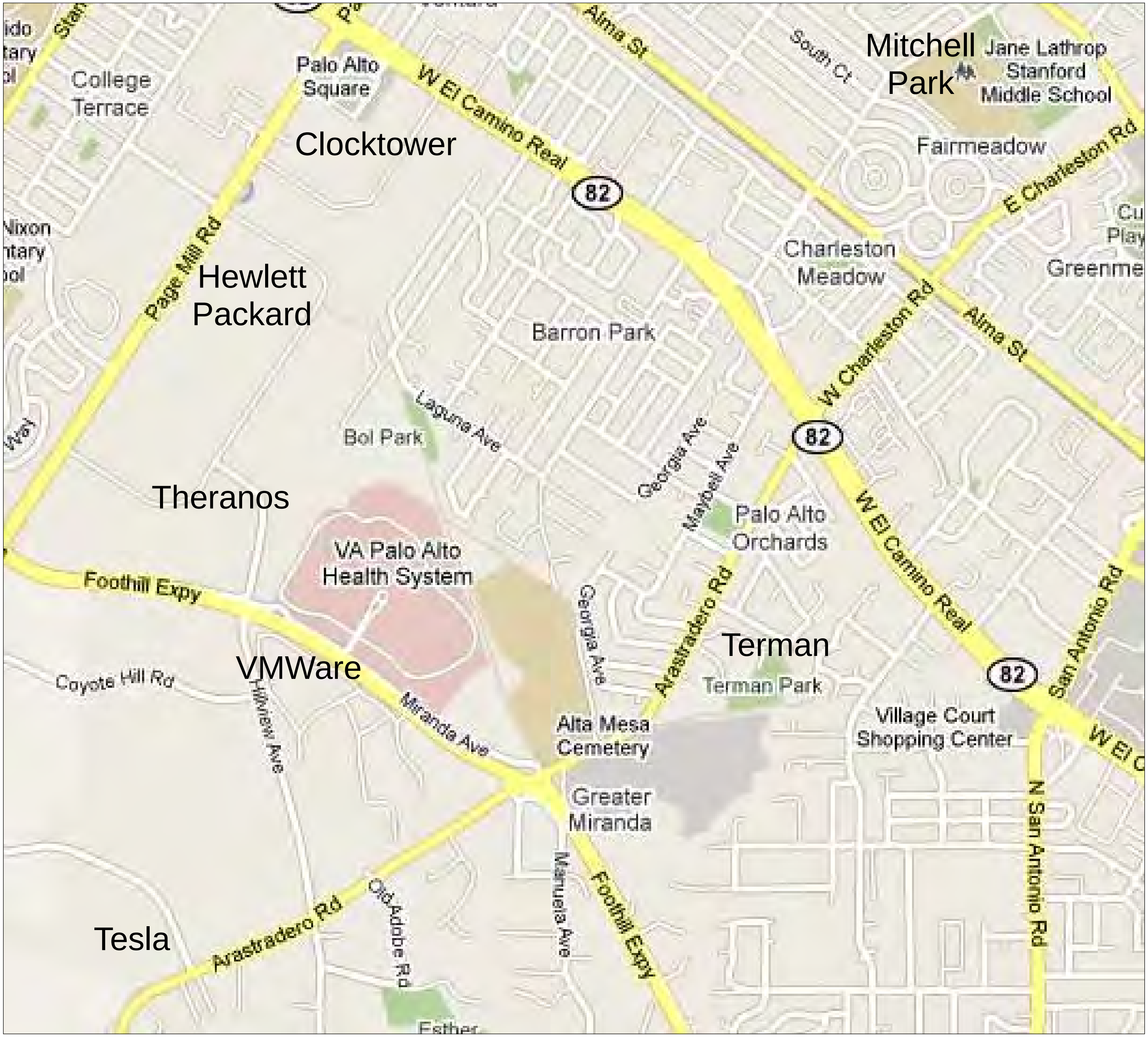
HortScience, Inc.

Nelda Matheny

Nelda Matheny, M. S.
Board Certified Master Arborist WE-0195B
Registered Consulting Arborist #243

Attachments: Study Site Locations Map
All Sites Tree Count
Theranos Tree Count
VMware Tree Count
Clocktower Tree Count
Mitchell Park Tree Count
Terman Park and School Tree Count
Hewlett Packard Tree Count
Tesla Motors Tree Count

Fig. 1
Study Site Locations



Palo Alto Recycled Water Project

Phase 3

Property

Theranos
3200 Hillview

VMWare
3401 Hillview

Clocktower
600-660 Hansen Wy.

Mitchell Park
600 East Meadow Dr.

Terman Park
655 Arastradero Rd.

Hewlett Packard
3000 Hanover St.

Tesla Motors
3500 Deer Creek Rd.

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All Sites - Tree Count
Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Callistemon viminalis	Weeping bottlebrush	high	16	
Casuarina cunninghamiana	River she-oak	high	69	
Cupressus arizonica	Arizona cypress	high	1	
Eucalyptus camadulensis	River red gum	high	2	
Eucalyptus globulus	Blue gum	high	60	
Eucalyptus globulus 'Compacta'	Dwarf blue gum	high	6	
Eucalyptus leucoxylon	White ironbark	high	24	
Eucalyptus polyanthemos	Silver dollar gum	high	24	
Eucalyptus sideroxylon	Red ironbark	high	3	
Eucalyptus viminalis	Manna gum	high	3	
Gleditsia triacanthos	Honeylocust	high	12	
Leptospermum scoparium	New Zealand tea tree	high	39	
Maytenus boaria	Mayten	high	16	
Olea europaea	Olive	high	20	
Pinus canariensis	Canary Island pine	high	65	
Pinus halepensis	Aleppo pine	high	22	
Pinus radiata	Monterey pine	high	53	
Pyrus calleryana	Callery pear	high	14	
Pyrus kawakamii	Evergreen pear	high	22	
Quercus agrifolia	Coast live oak	high	344	113
Quercus ilex	Holly oak	high	13	
Quercus macrocarpa	Burr oak	high	4	
Quercus rubra	Red oak	high	50	
Quercus suber	Cork oak	high	4	
Quercus virginiana	Southern live oak	high	64	
Querus robur 'Fastigiata'	Fastigate English oak	high	3	
Robinia pseudoacacia	Black locust	high	1	
Schinus molle	California pepper	high	39	
Schinus terebinthifolius	Brazillian pepepr	high	5	
Trachycarpus fortunei	Windmill palm	high	5	
Pinus pinea	Italian stone pine	high	32	
Acer palmatum	Japanese maple	low	27	
Acer rubrum	Red maple	low	41	

All Sites - Tree Count
Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Aesculus californica	California buckeye	low	10	
Albizia julibrissin	Silk tree	low	4	
Alnus rhombifolia	White alder	low	27	
Betula pendula	European white birch	low	31	
Calocedrus decurrens	Incense cedar	low	2	
Celtis occidentalis	Common hackberry	low	4	
Cercis canadensis	Eastern redbud	low	26	
Citrus x limon	Lemon	low	1	
Diospyros kaki	Persimmon	low	2	
Fagus sylvatica 'Autropunicea'	Copper beech	low	1	
Lagerstroemia indica	Crape myrtle	low	22	
Liquidambar stryraciflua	Sweet gum	low	148	
Liriodendron tulipifera	Tulip tree	low	19	
Magnolia grandiflora	Southern magnolia	low	60	
Magnolia soulangiana	Tulip magnolia	low	1	
Malus domestica	Apple	low	3	
Malus floribunda	Flowering crabapple	low	18	
Metasequoia glyptostroboides	Dawn redwood	low	8	
Michelia doltsopa	Michelia	low	6	
Pinus patula	Jelecote pine	low	1	
Prunus armeniaca	Apricot	low	1	
Prunus serrulata	Flowering cherry	low	5	
Prunus x yedoensis 'Akebono'	Flowering cherry	low	3	
Salix babylonica	Weeping willow	low	1	
Salix	Willow	low	1	
Sequoia sempervirens	Coast redwood	low	325	266
Sequoiadendron giganteum	Giant sequoia	low	7	
Taxus baccata	English yew	low	14	
Tilia tomentosa 'Sterling Silver'	Silver linden	low	7	
Acacia baileyana	Bailey's acacia	moderate	7	
Acacia melanoxylon	Blackwood acacia	moderate	6	
Acer platanoides	Norway maple	moderate	1	
Arbutus unedo	Strawberry tree	moderate	16	

All Sites - Tree Count
Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Calodendrum capense	Cape chestnut	moderate	9	
Cedrus atlantica	Atlas cedar	moderate	4	
Cedrus deodara	Deodar cedar	moderate	25	
Ceratonia siliqua	Carob	moderate	11	
Cercidiphyllum japonicum	Katsura tree	moderate	2	
Cercis occidentalis	Western redbud	moderate	17	
Cinnamomum camphora	Camphor	moderate	10	
Crataegus laevigata	English hawthorn	moderate	8	
Cupressus macrocarpa	Monterey cypress	moderate	21	
Eriobotrya japonica	Loquat	moderate	4	
Fraxinus angustifolia 'Raywood'	Raywood ash	moderate	28	
Fraxinus pennsylvanica ' Cimmzam'	Cimmaron ash	moderate	6	
Fraxinus uhedi	Evergreen ash	moderate	61	
Geijera parviflora	Australian willow	moderate	5	
Ginkgo biloba	Maidenhair tree	moderate	73	
Juglans hindsii	California black walnut	moderate	1	
Juniperus chinensis 'Kaizuka'	Hollywood juniper	moderate	6	
Ligustrum lucidum	Glossy privet	moderate	9	
Lophostemon confertus	Brisbane box	moderate	18	
Melaleuca quinquenervia	Cajeput tree	moderate	4	
Morus alba	Mulberry	moderate	9	
Pistacia chinensis	Chinese pistache	moderate	81	
Platanus x acerfolia	London plane	moderate	127	
Podocarpus macrophyllus	Yew pine	moderate	5	
Populus Fremontii	Fremont cottonwood	moderate	20	
Prunus cerasifera ' Atropurpurea'	Purple-leaf plum	moderate	62	
Quercus lobata	Valley oak	moderate	30	67
Robinia x ambigua ' Purple Robe'	Locust	moderate	23	
Tipuana tipu	Tipu tree	moderate	3	
Ulmus parvifolia	Chinese elm	moderate	36	
Total number trees			**2609**	**446**

Theranos Tree Count
3200 Hillview, Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Acer platanoides	Norway maple	moderate	1	
Callistemon viminalis	Weeping bottlebrush	high	6	
Cercidiphyllum japonicum	Katsura tree	moderate	2	
Cercis occidentalis	Western redbud	moderate	1	
Eucalyptus polyanthemos	Silver dollar gum	high	1	
Fraxinus angustifolia 'Raywood'	Raywood ash	moderate	7	
Lagerstroemia indica	Crape myrtle	low	9	
Lophostemon confertus	Brisbane box	moderate	16	
Melaleuca quinquenervia	Cajeput tree	moderate	1	
Olea europaea	Olive	high	3	
Pinus canariensis	Canary Island pine	high	8	
Pinus radiata	Monterey pine	high	14	
Quercus agrifolia	Coast live oak	high	2	4
Quercus rubra	Red oak	high	4	
Quercus virginiana	Southern live oak	high	20	

VMware Tree Count
3401 Hillview, Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Acer palmatum	Japanese maple	low	23	
Aesculus californica	California buckeye	low	10	
Alnus rhombifolia	White alder	low	22	
Cedrus deodara	Deodar cedar	moderate	1	
Cercis canadensis	Eastern redbud	low	25	
Cupressus macrocarpa	Monterey cypress	moderate	21	
Eucalyptus globulus	Blue gum	high	35	
Eucalyptus sideroxylon	Red ironbark	high	1	
Ginkgo biloba	Maidenhair tree	moderate	27	
Magnolia grandiflora 'Little Gem'	Little Gem magnolia	low	31	
Maytenus boaria	Mayten	high	12	
Metasequoia glyptostroboides	Dawn redwood	low	8	
Michelia doltsopa	Michelia	low	5	
Pinus canariensis	Canary Island pine	high	36	
Pinus radiata	Monterey pine	high	11	
Pistacia chinensis	Chinese pistache	moderate	41	
Platanus x acerifolia	London plane	moderate	50	
Populus Fremontii	Fremont cottonwood	moderate	20	
Prunus serrulata	Flowering cherry	low	1	
Quercus agrifolia	Coast live oak	high	115	7*
Quercus suber	Cork oak	high	1	
Robinia x ambigua ' Purple Robe'	Locust	moderate	23	
Schinus molle	California pepper	high	35	
Sequoia sempervirens 'Soquel'	Coast redwood	low	67	107
Ulmus parvifolia	Chinese elm	moderate	5	

*Three trees in decline, with removal notices attached

Clocktower Tree Count
600-660 Hansen Way, Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Acacia melanoxylon	Blackwood acacia	moderate	1	
Acer palmatum	Japanese maple	low	2	
Alnus rhombifolia	White alder	low	1	
Arbutus unedo	Strawberry tree	moderate	4	
Betula pendula	European white birch	low	22	
Cedrus deodara	Deodar cedar	moderate	12	
Eucalyptus globulus	Blue gum	high	20	
Eucalytpus polyanthemos	Silver dollar gum	high	3	
Fraxinus uhdei	Evergreen ash	moderate	40	
Liquidambar stryraciflua	Sweet gum	low	44	
Magnolia grandiflora	Southern magnolia	low	1	
Magnolia soulangiana	Tulip magnolia	low	1	
Michelia doltsopa	Michelia	low	1	
Pinus canariensis	Canary Island pine	high	5	
*Prunus cerasifera '*Atropurpurea'	Purple-leaf plum	moderate	11	
*Prunus x yedoensis '*Akebono'	Flowering cherry	low	3	
Pyrus kawakamii	Evergreen pear	high	12	
Quercus agrifolia	Coast live oak	high	3	0
Quercus ilex	Holly oak	high	2	
*Sequoia sempervirens '*Soquel'	Coast redwood	low	22	25

Mitchell Park Tree Count
3800 Middlefield Rd., Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Acer rubrum	Red maple	low	41	
Albizia julibrissin	Silk tree	low	1	
Betula pendula	European white birch	low	2	
Calodendrum capense	Cape chestnut	moderate	9	
Casurina cunninghamiana	River she-oak	high	10	
Cedrus atlantica 'Glauca'	Atlas cedar	moderate	1	
Cedrus deodara	Deodar cedar	moderate	11	
Celtis occidentalis	Common hackberry	low	4	
Ceratonia siliqua	Carob	moderate	11	
Cinnamomum camphora	Camphor	moderate	7	
Cupressus arizonica	Arizona cypress	high	1	
Eucalyptus polyanthemos	Silver dollar gum	high	17	
Fraxinus pennsylvanica 'Cimmzam'	Cimmaron ash	moderate	6	
Fraxinus uhedi	Evergreen ash	moderate	19	
Ginkgo biloba	Maidenhair tree	moderate	7	
Juglans hindsii	California black walnut	moderate	1	
Juniperus chinensis 'Kaizuka'	Hollywood juniper	moderate	5	
Liquidambar styraciflua	Sweetgum	low	1	
Magnolia grandiflora	Southern magnolia	low	4	
Malus floribunda	Flowering crabapple	low	5	
Maytenus boaria	Mayten	high	3	
Morus alba	Mulberry	moderate	8	
Olea europaea	Olive	high	13	
Pinus canariensis	Canary Island pine	high	13	
Pinus patula	Jelecote pine	low	1	
Pinus pinea	Italian stone pine	high	22	
Pinus radiata	Monterey pine	high	16	
Pistacia chinensis	Chinese pistache	moderate	1	
Platanus x acerifolia 'Bloodgood'	London plane	moderate	33	
Podocarpus marcrophyllus 'Maki'	Yew pine	moderate	2	

Mitchell Park Tree Count
3800 Middlefield Rd., Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Pyrus calleryana	Callery pear	high	13	
Quercus agrifolia	Coast live oak	high	0	1
Quercus ilex	Holly oak	moderate	9	
Quercus lobata	Valley oak	moderate	0	1
Quercus macrocarpa	Burr oak	high	3	
Quercus suber	Cork oak	high	3	
Salix babylonica	Weeping willow	moderate	1	
Schinus molle	California pepper	high	2	
Schinus terebinthifolius	Brazillian pepepr	high	1	
Sequoia sempervirens	Coast redwood	low	8	16
Taxus baccata	English yew	low	14	
Tilia tomentosa 'Sterling Silver'	Silver linden	low	7	
Trachycarpus fortunei	Windmill palm	high	5	
Ulmus parvifolia	Chinese evergreen elm	moderate	3	

Terman Park and School Tree Count
655 Arastradero Rd., Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Acacia baileyana	Bailey acacia	moderate	3	
Acer palmatum	Japanese maple	low	1	
Alnus rhombifolia	White alder	low	4	
Arbutus unedo	Strawberry tree	moderate	3	
Betula pendula	European white birch	low	7	
Calocedrus decurrens	Incense cedar	low	2	
Cinnamomum camphora	Camphor	moderate	2	
Citrus x limon	Lemon	low	1	
Crataegus laevigata	English hawthorn	moderate	2	
Diospyros kaki	Persimmon	low	1	
Eriobotrya japonica	Loquat	moderate	1	
Eucalyptus polyanthemos	Silver dollar gum	high	1	
Eucalyptus sideroxylon	Red ironbark	high	1	
Fraxinus angustifolia 'Raywood'	Raywood ash	moderate	8	
Fraxinus uhdei	Evergreen ash	moderate	1	
Juniperus chinensis 'Kaizuka'	Hollywood juniper	high	1	
Lagerstroemia indica	Crape myrtle	low	2	
Ligustrum lucidum	Glossy privet	moderate	3	
Liquidambar stryraciflua	Sweet gum	low	16	
Magnolia grandiflora	Southern magnolia	low	11	
Malus domestica	Apple	low	3	
Malus floribunda	Flowering crabapple	low	1	
Maytenus boaria	Mayten	high	1	
Morus alba	Mulberry	moderate	1	
Pinus halepensis	Aleppo pine	high	2	
Pinus radiata	Monterey pine	high	1	
Prunus armeniaca	Apricot	low	1	
Prunus cerasifera 'Autropurpurea'	Purple-leaf plum	moderate	20	
Quercus agrifolia	Coast live oak	high	2	13
Quercus rubra	Red oak	high	3	
Schinus molle	California pepper	high	2	
Schinus terebinthifolius	Brazilian pepper	high	2	
Sequoia sempervirens	Coast redwood	low	20	24
Ulmus parvifolia	Chinese evergreen elm	moderate	6	

Hewlett Packard Tree Count
3000 Hanover St., Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Acer palmatum	Japanese maple	low	1	
Albizzia julibrissin	Silk tree	low	3	
Arbutus unedo	Strawberry tree	moderate	6	
Callistemon viminalis	Weeping bottlebrush	high	10	
Cedrus atlantica	Atlas cedar	moderate	3	
Cedrus deodara	Deodar cedar	moderate	1	
Cercis canadensis	Eastern redbud	low	1	
Cercis occidentalis	Western redbud	moderate	16	
Diospyros kaki	Persimmon	low	1	
Eryobotrya japonica	Loquat	moderate	3	
Eucalyptus polyanthemos	Silver dollar gum	high	2	
Eucalyptus sideroxylon	Red ironbark	high	1	
Fagus sylvatica 'Autropunicea'	Copper beech	low	1	
Fraxinus augustifolia 'Raywood'	Raywood ash	moderate	13	
Fraxinus uhdei	Evergreen ash	moderate	1	
Geijera parviflora	Australian willow	moderate	5	
Ginkgo biloba	Maidenhair tree	moderate	39	
Gleditsia triacanthos	Honeylocust	high	12	
Lagerstroemia indica	Crape myrtle	low	5	
Leptospermum scoparium	New Zealand tea tree	high	39	
Ligustrum lucidum	Glossy privet	moderate	6	
Liquidambar stryraciflua	Sweet gum	low	87	
Liriodendron tulipifera	Tulip tree	low	19	
Magnolia grandiflora	Southern magnolia	low	13	
Olea europaea	Olive	high	4	
Pinus canariensis	Canary Island pine	high	2	
Pinus halepensis	Aleppo pine	high	20	
Pinus pinea	Italian stone pine	high	5	
Pinus radiata	Monterey pine	high	11	
Pistacia chinensis	Chinese pistache	moderate	16	
Platanus x acerifolia	London plane	moderate	37	

Hewlett Packard Tree Count
3000 Hanover St., Palo Alto

HORT SCIENCE

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Podocarpus macrophyllus	Yew pine	moderate	3	
Prunus cerasifera 'Autropurpurea'	Purple-leaf plum	moderate	11	
Pyrus calleryana	Callery pear	high	1	
Pyrus kawakamii	Evergreen pear	high	10	
Quercus agrifolia	Coast live oak	high	22	7
Quercus ilex	Holly oak	moderate	2	
Quercus lobata	Valley oak	moderate	10	40
Quercus macrocarpa	Burr oak	high	1	
Quercus rubra	Red oak	high	43	
Quercus virginiana	Southern live oak	high	44	
Robinia pseudoacacia	Black locust	high	1	
Schinus terebinthifolius	Brazilian pepper	high	2	
Sequoia sempervirens 'Soquel'	Coast redwood	low	208	94
Sequoiadendron giganteum	Giant sequoia	low	7	
Ulmus parvifolia	Chinese evergreen elm	moderate	22	

Tesla Motors Tree Count
3500 Deer Creek Rd., Palo Alto

Scientific Name	Common Name	Salt Tolerance	# Trees Not Protected	# Trees Protected
Acacia baileyana	Bailey's acacia	moderate	4	
Acacia melanoxylon	Blackwood acacia	moderate	5	
Arbutus unedo	Strawberry tree	moderate	3	
Casurina cunninghamiana	River she-oak	high	59	
Cinnamomum camphora	Camphor	moderate	1	
Crataegus laevigata	English hawthorn	moderate	6	
Eucalyptus camadulensis	River red gum	high	2	
Eucalyptus globulus	Blue gum	high	5	
Eucalyptus globulus 'Compacta'	Dwarf blue gum	high	6	
Eucalyptus leucoxylon	White ironbark	high	24	
Eucalyptus viminalis	Manna gum	high	3	
Lagerstroemia indica	Crape myrtle	low	6	
Lophostemon confertus	Brisbane box	moderate	2	
Malus floribunda	Flowering crab apple	low	12	
Melaleuca quinquenervia	Cajeput tree	moderate	3	
Pinus canariensis	Canary island pine	high	1	
Pinus pinea	Italian stone pine	high	5	
Pistacia chinensis	Chinese pistache	moderate	23	
Platanus x acerfolia	London plane	moderate	7	
Prunus cerasifera 'Atropurpurea'	Purple-leaf plum	moderate	20	
Prunus serrulata	Flowering cherry	low	4	
Quercus agrifolia	Coast live oak	high	200	81
Quercus lobata	Valley oak	moderate	20	26
Querus robur 'Fastigiata'	Fastigate English oak	high	3	
Salix	Willow	low	1	
Tipuana tipu	Tipu tree	moderate	3	

Appendix I – Air Quality Emissions Calculations

General Emission Thresholds

BAAQMD	Construction (lbs/day)	Operation (lbs/day)	Operation (tons/year)
ROG	54	54	10
NOx	54	54	10
CO	None	None	None
SO2	None	None	None
PM10	82	82	15
PM2.5	54	54	10

	Maximum Daily Construction Emission (lbs/day)						Construction GHG
	VOC	NOx	CO	SO2	PM10	PM2.5	CO2e (lbs/day)
Pipeline - 2 Crews[2]	8.70	85.0	53.0		7.20	4.10	13,428
Pipeline - HDD 2 Crews[2]	4.80	34.8	31.4		1.20	1.30	7,459
Pipeline - 1 Crew[2]	4.80	51.1	28.8		4.30	2.40	8,737
Pump Station - Soccer Field[1]	3.57	41.1	42.9	1.20E-01	4.48	2.09	11,521
Pump Station - RWQCP[1]	1.68	17.5	18.0	4.25E-02	2.23	1.26	4,073
BAAQMD Thresholds[3]	54	54	None	None	82	54	NONE
	Maximum Daily Operation Emission (lbs/day)						**Operation GHG**
	VOC	NOx	CO	SO2	PM10	PM2.5	CO2e (lbs/day)
Pump Station - Soccer Field[4]	-	-	-	-	-	-	2,688
Pump Station - RWQCP[4]	-	-	-	-	-	-	2,352
Total	-	-	-	-	-	-	5,040
BAAQMD Thresholds[3]	54	54	None	None	82	54	NONE

	Overall Annual Construction Emission (tons/year)						Construction GHG
	VOC	NOx	CO	SO2	PM10	PM2.5	CO2e (MT/yr)
Pipeline - 2 Crews[2]	1.00	8.90	5.90		0.80	0.50	1,311
Pipeline - HDD 2 Crews[2]	0.60	3.90	4.20		0.20	0.20	883
Pipeline - 1 Crew[2]	0.50	5.10	3.20		0.50	0.30	802
Pump Station - Soccer Field[1]	0.10	1.14	1.00	2.58E-03	0.11	0.06	225
Pump Station - RWQCP[1]	0.07	0.76	0.65	1.30E-03	0.07	0.05	114
Federal General Conformity Thresholds[3]	50	100	100	100	100	100	NONE
	Annual Operation Emission (tons/year)						**Operation GHG**
	VOC	NOx	CO	SO2	PM10	PM2.5	CO2e (MT/yr)
Pump Station - Soccer Field[4]	-	-	-	-	-	-	491
Pump Station - RWQCP[4]	-	-	-	-	-	-	430
Total	-	-	-	-	-	-	920
BAAQMD Thresholds[3]	10	10	None	None	15	10	1,100

Operation		
Power	750	hp
Daily Energy Consumption	14,129	kWh/day
	14	MWH/day
Annual Energy Consumption	5,160,636	kWh/yr
	5,161	MWH/yr
Backup Generator	0	kW

Operation Daily GHG Emission

Constituents		
CO2	5,005	lbs/day
CH4	0.410	lbs/day
N2O	0.0848	lbs/day
CO2e	5,040	lbs/day

Operation Annual GHG Emission

Constituents		
CO2	1,828,207	lbs/yr
CH4	150	lbs/yr
N2O	31.0	lbs/yr
CO2e	920	tons/yr

1. Using CalEEMod model assuming incorporation of standard mitigation measures.
2. Using RoadMod model assuming incorporation of standard mitigation measures.
3. Thresholds are based on BAAQMD Guidelines (BAAQMD 2009) and General Conformity De Minimis Levels for the San Francisco Bay Area Air Basin (EPA 2014)
4. GHG Operations Emissions are based on the energy use of the pump stations.

Pipeline Component Assumptions

Project Working Day Schedule	**Days**	**Month**
Assuming 5 days/week	240	12.0
Max Speed for Large Pipe	200	LF/day
Max Speed for Small Pipe	300	LF/day
Max Speed for Material Import/Export	200	LF/day
Disturbed Area	30	ft

Assuming project alignment is constructed linearly with no overlapping component

	Pipeline Description					**Disturbed Acreage**			**Import/Export Soil**			
Parameters	**RW Pipe Length**		**Trench Width**	**Bedding and Filling Depth**	**Pipe Diameter**	**Disturb Total**	**Disturb Max. Daily**		**Import Max. Daily**	**Export Max. Daily**	**Total Import**	**Total Export**
Units	**miles**	**feet**	**feet**	**feet**	**in**	**acres**	**acres**		**CY**	**CY**	**CY**	**CY**
30	0.2	**792**	4.5	7.5	**30**	0.5	0.14	28.84	213.6	250.0	846.0	990.0
24	0.2	**845**	4.0	7.0	**24**	0.6	0.14	24.86	184.1	207.4	777.8	876.1
18	2.5	**13,300**	3.5	6.0	**18**	9.2	0.14	19.23	142.5	155.6	9,474.0	10,344.4
16	2.0	**10,300**	3.3	6.0	**16**	7.1	0.14	18.60	137.8	148.1	7,097.0	7,629.6
12	0.4	**2,100**	3.0	6.0	**12**	1.4	0.14	17.21	127.5	133.3	1,338.9	1,400.0
10	1.2	**6,500**	2.8	5.0	**10**	4.5	0.14	13.62	100.9	104.9	3,279.2	3,410.5
6	1.6	**8,300**	2.5	5.0	**6**	5.7	0.14	12.30	91.1	92.6	3,782.2	3,842.6
4	2.2	**11,400**	2.3	5.0	**4**	7.9	0.207	11.58	128.7	129.6	4,889.1	4,925.9
Total - 2 Crews	9.83	51,900	-	-	-	36.87	0.34		265.3	303.7	35,840.7	37,775.7
Daily Average - 2 Crews	-	**216**	-	-	-	**0.15**	-		-	-	**149.34**	**157.40**
Total - 1 crew	4.9	25,950				18.44	0.10		127.5	133.3	17,920.3	18,887.8
Daily Average - 1 Crew		**108**									**74.67**	**78.70**

Pipeline

Pipe Size (in)	Length (ft)	Length (yrds)	Pipe plus 50% (in)	r of tunnel (ft)	Area of tunnel (ft2)	Area of tunnel (yd2)	Cubic Volume (ft)	Cubic Volume (yrds)	truck trips	duration (days/yr)	truck trips/day
30	792	264	45	1.88	11.04	1.23	8,747	324			
24	845	282	36	1.50	7.07	0.785	5,972	221			
18	13,300	4,433	27	1.13	3.98	0.442	52,882	1,959			
16	10,300	3,433	24	1.00	3.14	0.349	32,358	1,198			
12	2,100	700	18	0.750	1.77	0.196	3,711	137			
10	6,500	2,167	15	0.625	1.23	0.136	7,977	295			
6	8,300	2,767	9	0.375	0.442	0.0491	3,667	136			
4	11,400	3,800	6	0.250	0.196	0.0218	2,238	82.9			
TOTAL	53,537	17,846	180	7.50	176.71	20	117,552	**4,354**	**435**	**240**	**1.81**

Pipeline Pits

Space Between Pits (ft)	Number of Pits	Pit Area (ft2)	Pit Depth (ft)	Pit Volume (ft3)	Pit Volume (yd3)	Total Pit Cubic Volume (yds)
750	71.38	10	8	80	2.96	**211.5**

Crossings

Feature	Pipe Size (in)	Pipe Size (ft)	Pipe plus 50% (ft)	r of tunnel (ft)	Area of tunnel (ft2)	Area of tunnel (yd2)	Length (ft)	Length (yds)	Pit Area (ft2)	Pit Depth (ft)	Pit Volume (ft3)	Pit Volume (yd3)	Cubic Volume (ft)	Cubic Volume (yrds)
Alma/Caltrain	16	1.33	2	1	3.14	0.349	200	66.67	10	15	150	5.56	778.3	28.8
US 101	18	1.50	2.25	1.125	3.98	0.442	200	66.67	10	15	150	5.56	945.2	35.0
El Camino Real	16	1.33	2	1	3.14	0.349	400	133.33	10	15	150	5.56	1406.6	52.1
Foothill Expy	16	1.33	2	1	3.14	0.349	400	133.33	10	15	150	5.56	1406.6	52.1
Adobe @ 101	18	1.50	2.25	1.125	3.98	0.442	100	33.33	10	15	150	5.56	547.6	20.3
Adobe @ E Meadow	18	1.50	2.25	1.125	3.98	0.442	100	33.33	10	15	150	5.56	547.6	20.3
Adobe @ Middlefield	6	0.50	0.75	0.375	0.442	0.049	75	25	10	15	150	5.56	183.1	6.8
Barron @ Cowper	18	1.50	2.25	1.125	3.98	0.442	75	25	10	15	150	5.56	448.2	16.6
Matadero @ Cowper	18	1.50	2.25	1.125	3.98	0.442	75	25	10	15	150	5.56	448.2	16.6
Matadero @ Hillview	16	1.33	2	1	3.14	0.349	75	25	10	15	150	5.56	385.6	14.3
Barron @ Footfill Expy	10	0.83	1.25	0.625	1.23	0.136	75	25	10	15	150	5.56	242.0	9.0
TOTAL					34.12	3.79	1775	591.667	110	165	1650	61.11	7339.2	**543.6**

truck trips	duration (days/yr)	truck trips/day
54.4	240	0.227

TOTAL Volume Removed	truck trips	duration	truck/day
5108.9	510.9	240	2.13

TOTAL Area Disturbed	Max Area Disturbed (ft2/day)
0.46	550
	Max Area Disturbed (acre/day)
	0.013

Pump Station - Soccer Field

Construction Schedule

Phases	Week
Site Preparation	1
Grading	6
Building Construction	16
Architectural Coating	0
Paving	1
Total	24

Construction Details

General Description		
Pump Station Size	400	hp
Disturbed Acreage	0.05	Acre
Pump Station Building Width	50	ft
Pump Station Building Length	30	ft
Height	25	ft
Footprint	0.034	Acre
Footprint from DPR map	-	Acre

Material Export		
Grading Excavation (Export)	0	Cubic Yard
Foundation Width	4	ft
Foundation Depth	10	ft
Maximum Construction Depth	25	ft
Foundation Material	213	Cubic Yard
Total Export Volume	37,500	Cubic Yard
	3750	Total Hauling Trips

Material Import		
Foundation Material (Import)	213	Cubic Yard
Building Wall Thickness	0.7	ft
Building Floor Thickness	1.0	ft
Building Material (Import)	153	Cubic Yard
Total Import Volume	366	Cubic Yard

Operation Details

Operation		
Power	400	hp
Annual Energy Consumption	2,752,339	kWh/Yr

Pump Station - RWQCP

Construction Schedule

Phases	Week
Site Preparation	1
Grading	6
Building Construction	16
Architectural Coating	0
Paving	1
Total	24

Construction Details

General Description		
Pump Station Size	350	hp
Disturbed Acreage	0.05	Acre
Pump Station Building Width	40	ft
Pump Station Building Length	42	ft
Height	12	ft
Footprint	0.039	Acre
Footprint from DPR map	-	Acre

Material Export		
Grading Excavation (Export)	0	Cubic Yard
Foundation Width	4	ft
Foundation Depth	10	ft
Maximum Construction Depth	6	ft
Foundation Material	219	Cubic Yard
Total Export Volume	10,080	Cubic Yard
	1008	Total Hauling Trips

Material Import		
Foundation Material (Import)	219	Cubic Yard
Building Wall Thickness	0.7	ft
Building Floor Thickness	1.0	ft
Building Material (Import)	110	Cubic Yard
Total Import Volume	329	Cubic Yard

Operation Details

Operation		
Power	350	hp
Annual Energy Consumption	2,408,297	kWh/Yr

Open Trench Construction - 2 Crews

Road Construction Emissions Model, Version 7.1.5.1

Emission Estimates for -> Pasadena RW Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	7.0	38.5	60.0	6.2	2.8	3.4	3.2	2.5	0.7	7,609.1
Grading/Excavation	8.7	53.0	85.0	7.2	3.8	3.4	4.1	3.4	0.7	13,427.5
Drainage/Utilities/Sub-Grade	8.0	44.1	66.4	6.9	3.5	3.4	3.9	3.2	0.7	8,508.2
Paving	3.7	23.7	21.7	1.3	1.3	-	1.1	1.1	-	3,828.5
Maximum (pounds/day)	8.7	53.0	85.0	7.2	3.8	3.4	4.1	3.4	0.7	13,427.5
Total (tons/construction project)	1.0	5.9	8.9	0.8	0.4	0.4	0.5	0.4	0.1	1,310.8

Notes:	
Project Start Year ->	2019
Project Length (months) ->	12
Total Project Area (acres) ->	37
Maximum Area Disturbed/Day (acres) ->	0
Total Soil Imported/Exported (yd^3/day)->	307

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Horizontal Directional Drilling - 2 Crews

Road Construction Emissions Model, Version 7.1.5.1

Emission Estimates for -> Pasadena RW Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	-	-	-	-	-	-	-	-	-	-
Grading/Excavation	4.8	31.4	34.8	1.6	1.5	0.1	1.3	1.3	0.0	7,470.6
Drainage/Utilities/Sub-Grade	-	-	-	-	-	-	-	-	-	-
Paving	4.1	26.7	26.7	1.4	1.4	-	1.3	1.3	-	4,525.7
Maximum (pounds/day)	4.8	31.4	34.8	1.6	1.5	0.1	1.3	1.3	0.0	7,470.6
Total (tons/construction project)	0.6	4.0	4.4	0.2	0.2	0.0	0.2	0.2	0.0	908.4

Notes: Project Start Year -> 2019

Project Length (months) -> 12

Total Project Area (acres) -> 3

Maximum Area Disturbed/Day (acres) -> 0

Total Soil Imported/Exported (yd^3/day)-> 24

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Open Trench Construction - 1 Crew

Road Construction Emissions Model, Version 7.1.5.1

Emission Estimates for -> Pasadena RW Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	3.5	19.3	30.3	3.5	1.4	2.1	1.7	1.2	0.4	3,874.9
Grading/Excavation	4.8	28.8	51.1	4.3	2.2	2.1	2.4	1.9	0.4	8,736.9
Drainage/Utilities/Sub-Grade	4.3	23.8	35.9	4.0	1.9	2.1	2.2	1.8	0.4	4,676.4
Paving	2.1	14.6	13.5	0.8	0.8	-	0.7	0.7	-	2,368.4
Maximum (pounds/day)	4.8	28.8	51.1	4.3	2.2	2.1	2.4	1.9	0.4	8,736.9
Total (tons/construction project)	0.5	3.2	5.1	0.5	0.2	0.2	0.3	0.2	0.0	802.2

Notes:

Project Start Year ->	2019
Project Length (months) ->	12
Total Project Area (acres) ->	36
Maximum Area Disturbed/Day (acres) ->	0
Total Soil Imported/Exported (yd^3/day)->	307

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Palo Alto Recycled Water Facility - RWQCP

Santa Clara County, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric	Lot Acreage	Floor Surface Area	Population
User Defined Parking	1.00	User Defined Unit	0.04	1,680.00	0

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Precipitation Freq (Days)**	58
Climate Zone	4			**Operational Year**	2020
Utility Company	City of Palo Alto Public Utilities				
CO2 Intensity (lb/MWhr)	354.26	**CH4 Intensity (lb/MWhr)**	0.029	**N2O Intensity (lb/MWhr)**	0.006

1.3 User Entered Comments & Non-Default Data

Project Characteristics -

Land Use - Based on project assumptions of 42' x 40' maximum structure size with a footprint of the same size.

Construction Phase - Based on a 6 month construction period starting on January 1, 2019.

Grading - Based on Project Description.

Trips and VMT - Grading includes hauling of all excavated material.

Vehicle Trips - Based on one worker servicing the site with a 20 mile commute.

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2019	0.0744	0.7564	0.6531	1.3000e-003	0.0299	0.0397	0.0696	0.0115	0.0368	0.0483	0.0000	113.1083	113.1083	0.0192	0.0000	113.5116
Total	**0.0744**	**0.7564**	**0.6531**	**1.3000e-003**	**0.0299**	**0.0397**	**0.0696**	**0.0115**	**0.0368**	**0.0483**	**0.0000**	**113.1083**	**113.1083**	**0.0192**	**0.0000**	**113.5116**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2019	0.0744	0.7564	0.6531	1.3000e-003	0.0299	0.0397	0.0696	0.0115	0.0368	0.0483	0.0000	113.1082	113.1082	0.0192	0.0000	113.5115
Total	**0.0744**	**0.7564**	**0.6531**	**1.3000e-003**	**0.0299**	**0.0397**	**0.0696**	**0.0115**	**0.0368**	**0.0483**	**0.0000**	**113.1082**	**113.1082**	**0.0192**	**0.0000**	**113.5115**

	ROG	**NOx**	**CO**	**SO2**	**Fugitive PM10**	**Exhaust PM10**	**PM10 Total**	**Fugitive PM2.5**	**Exhaust PM2.5**	**PM2.5 Total**	**Bio- CO2**	**NBio-CO2**	**Total CO2**	**CH4**	**N20**	**CO2e**
Percent Reduction	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Palo Alto Recycled Water Facility - RWQCP

Santa Clara County, Winter

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric	Lot Acreage	Floor Surface Area	Population
User Defined Parking	1.00	User Defined Unit	0.04	1,680.00	0

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Precipitation Freq (Days)**	58
Climate Zone	4			**Operational Year**	2020
Utility Company	City of Palo Alto Public Utilities				
CO2 Intensity (lb/MWhr)	354.26	**CH4 Intensity (lb/MWhr)**	0.029	**N2O Intensity (lb/MWhr)**	0.006

1.3 User Entered Comments & Non-Default Data

Project Characteristics -

Land Use - Based on project assumptions of 42' x 40' maximum structure size with a footprint of the same size.

Construction Phase - Based on a 6 month construction period starting on January 1, 2019.

Grading - Based on Project Description.

Trips and VMT - Grading includes hauling of all excavated material.

Vehicle Trips - Based on one worker servicing the site with a 20 mile commute.

2.1 Overall Construction (Maximum Daily Emission)

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2019	1.6837	17.4748	18.0226	0.0425	1.5695	0.6598	2.2294	0.6322	0.6254	1.2576	0.0000	4,065.5733	4,065.5733	0.3585	0.0000	4,073.1021
Total	**1.6837**	**17.4748**	**18.0226**	**0.0425**	**1.5695**	**0.6598**	**2.2294**	**0.6322**	**0.6254**	**1.2576**	**0.0000**	**4,065.5733**	**4,065.5733**	**0.3585**	**0.0000**	**4,073.1021**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2019	1.6837	17.4748	18.0226	0.0425	1.5695	0.6598	2.2294	0.6322	0.6254	1.2576	0.0000	4,065.5733	4,065.5733	0.3585	0.0000	4,073.1021
Total	**1.6837**	**17.4748**	**18.0226**	**0.0425**	**1.5695**	**0.6598**	**2.2294**	**0.6322**	**0.6254**	**1.2576**	**0.0000**	**4,065.5733**	**4,065.5733**	**0.3585**	**0.0000**	**4,073.1021**

	ROG	**NOx**	**CO**	**SO2**	**Fugitive PM10**	**Exhaust PM10**	**PM10 Total**	**Fugitive PM2.5**	**Exhaust PM2.5**	**PM2.5 Total**	**Bio- CO2**	**NBio-CO2**	**Total CO2**	**CH4**	**N20**	**CO2e**
Percent Reduction	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Palo Alto Recycled Water Facility - Soccer Field

Santa Clara County, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric	Lot Acreage	Floor Surface Area	Population
User Defined Parking	1.00	User Defined Unit	0.03	1,500.00	0

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Precipitation Freq (Days)**	58
Climate Zone	4			**Operational Year**	2020
Utility Company	City of Palo Alto Public Utilities				
CO2 Intensity (lb/MWhr)	354.26	**CH4 Intensity (lb/MWhr)**	0.029	**N2O Intensity (lb/MWhr)**	0.006

1.3 User Entered Comments & Non-Default Data

Project Characteristics -

Land Use - Based on project assumptions of 50' x 30' maximum structure size with a footprint of the same size.

Construction Phase - Based on a 6 month construction period starting on January 1, 2019.

Grading - Based on Project Description.

Trips and VMT - Grading includes hauling of all excavated material.

Vehicle Trips - Based on one worker servicing the site with a 20 mile commute.

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2019	0.1040	1.1403	0.9998	2.5800e-003	0.0605	0.0454	0.1059	0.0197	0.0421	0.0618	0.0000	224.7451	224.7451	0.0201	0.0000	225.1660
Total	**0.1040**	**1.1403**	**0.9998**	**2.5800e-003**	**0.0605**	**0.0454**	**0.1059**	**0.0197**	**0.0421**	**0.0618**	**0.0000**	**224.7451**	**224.7451**	**0.0201**	**0.0000**	**225.1660**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2019	0.1040	1.1403	0.9998	2.5800e-003	0.0605	0.0454	0.1059	0.0197	0.0421	0.0618	0.0000	224.7450	224.7450	0.0201	0.0000	225.1660
Total	**0.1040**	**1.1403**	**0.9998**	**2.5800e-003**	**0.0605**	**0.0454**	**0.1059**	**0.0197**	**0.0421**	**0.0618**	**0.0000**	**224.7450**	**224.7450**	**0.0201**	**0.0000**	**225.1660**

Palo Alto Recycled Water Facility - Soccer Field

Santa Clara County, Winter

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric	Lot Acreage	Floor Surface Area	Population
User Defined Parking	1.00	User Defined Unit	0.03	1,500.00	0

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.2	**Precipitation Freq (Days)**	58
Climate Zone	4			**Operational Year**	2020
Utility Company	City of Palo Alto Public Utilities				
CO2 Intensity (lb/MWhr)	354.26	**CH4 Intensity (lb/MWhr)**	0.029	**N2O Intensity (lb/MWhr)**	0.006

1.3 User Entered Comments & Non-Default Data

Project Characteristics -

Land Use - Based on project assumptions of 50' x 30' maximum structure size with a footprint of the same size.

Construction Phase - Based on a 6 month construction period starting on January 1, 2019.

Grading - Based on Project Description.

Trips and VMT - Grading includes hauling of all excavated material.

Vehicle Trips - Based on one worker servicing the site with a 20 mile commute.

2.0 Emissions Summary

2.1 Overall Construction (Maximum Daily Emission)

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2019	3.5688	41.1027	42.8745	0.1201	3.4765	1.0082	4.4847	1.1427	0.9459	2.0886	0.0000	11,513.5077	11,513.5077	0.3585	0.0000	11,521.0365
Total	**3.5688**	**41.1027**	**42.8745**	**0.1201**	**3.4765**	**1.0082**	**4.4847**	**1.1427**	**0.9459**	**2.0886**	**0.0000**	**11,513.5077**	**11,513.5077**	**0.3585**	**0.0000**	**11,521.0365**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	lb/day										lb/day					
2019	3.5688	41.1027	42.8745	0.1201	3.4765	1.0082	4.4847	1.1427	0.9459	2.0886	0.0000	11,513.5077	11,513.5077	0.3585	0.0000	11,521.0365
Total	**3.5688**	**41.1027**	**42.8745**	**0.1201**	**3.4765**	**1.0082**	**4.4847**	**1.1427**	**0.9459**	**2.0886**	**0.0000**	**11,513.5077**	**11,513.5077**	**0.3585**	**0.0000**	**11,521.0365**

12/04/14
07:47:46
*** SCREEN3 MODEL RUN ***
*** VERSION DATED 96043 ***
C:\Lakes\Screen View\Palo Alto_Construction_1 Crew.scr

SIMPLE TERRAIN INPUTS:
SOURCE TYPE = AREA
EMISSION RATE (G/(S-M**2)) = 0.401451E-04
SOURCE HEIGHT (M) = 4.5720
LENGTH OF LARGER SIDE (M) = 91.4400
LENGTH OF SMALLER SIDE (M) = 9.1440
RECEPTOR HEIGHT (M) = 1.5000
URBAN/RURAL OPTION = URBAN
THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = 0.000 M**4/S**3; MOM. FLUX = 0.000 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	MAX DIR (DEG)
2.	94.75	4	1.0	1.0	320.0	4.57	0.
100.	116.6	5	1.0	1.0	10000.0	4.57	0.
200.	35.07	5	1.0	1.0	10000.0	4.57	0.
300.	16.94	5	1.0	1.0	10000.0	4.57	0.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 2. M:

63.	176.8	5	1.0	1.0	10000.0	4.57	0.

****
*** SUMMARY OF SCREEN MODEL RESULTS ***
****

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	176.8	63.	0.

12/03/14
22:30:38
*** SCREEN3 MODEL RUN ***
*** VERSION DATED 96043 ***
C:\Lakes\Screen View\Palo Alto_Construction_PS RWQCP.scr

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	AREA
EMISSION RATE (G/(S-M**2))	=	0.686264E-04
SOURCE HEIGHT (M)	=	4.5000
LENGTH OF LARGER SIDE (M)	=	91.4400
LENGTH OF SMALLER SIDE (M)	=	9.1440
RECEPTOR HEIGHT (M)	=	1.5000
URBAN/RURAL OPTION	=	URBAN

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = 0.000 M**4/S**3; MOM. FLUX = 0.000 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	MAX DIR (DEG)
2.	166.6	4	1.0	1.0	320.0	4.50	0.
100.	201.0	5	1.0	1.0	10000.0	4.50	0.
200.	60.06	5	1.0	1.0	10000.0	4.50	0.
300.	28.98	5	1.0	1.0	10000.0	4.50	0.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 2. M:

62.	309.5	5	1.0	1.0	10000.0	4.50	0.

****
*** SUMMARY OF SCREEN MODEL RESULTS ***
****

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	309.5	62.	0.

```
12/03/14
22:33:56
  ***  SCREEN3 MODEL RUN  ***
  *** VERSION DATED 96043 ***
C:\Lakes\Screen View\Palo Alto_Construction_PS RWQCP.scr

 SIMPLE TERRAIN INPUTS:
    SOURCE TYPE                  =         AREA
    EMISSION RATE (G/(S-M**2))   =     0.217000E-04
    SOURCE HEIGHT (M)            =       4.5000
    LENGTH OF LARGER SIDE (M)    =      10.1078
    LENGTH OF SMALLER SIDE (M)   =      10.1078
    RECEPTOR HEIGHT (M)          =       1.5000
    URBAN/RURAL OPTION           =        URBAN
 THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
 THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS
ENTERED.

    MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION


 BUOY. FLUX =    0.000 M**4/S**3;  MOM. FLUX =    0.000 M**4/S**2.

 *** FULL METEOROLOGY ***

 **********************************
 *** SCREEN AUTOMATED DISTANCES ***
 **********************************

 *** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING
DISTANCES ***

   DIST     CONC             U10M   USTK  MIX HT   PLUME  MAX DIR
    (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   (DEG)
 -------  ----------  ----  -----  -----  ------  ------  -------
      2.   1.817        1     1.0    1.0   320.0    4.50     44.
    100.   6.971        5     1.0    1.0 10000.0    4.50     40.
    200.   2.224        5     1.0    1.0 10000.0    4.50     39.
    300.   1.099        5     1.0    1.0 10000.0    4.50     24.

 MAXIMUM 1-HR CONCENTRATION AT OR BEYOND     2. M:
     35.   16.75        4     1.0    1.0 10000.0    4.50     45.

      ***************************************
      *** SUMMARY OF SCREEN MODEL RESULTS ***
      ***************************************

  CALCULATION        MAX CONC    DIST TO   TERRAIN
   PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
 --------------    -----------   -------   -------
 SIMPLE TERRAIN      16.75          35.        0.
```

12/03/14
22:40:40
*** SCREEN3 MODEL RUN ***
*** VERSION DATED 96043 ***
C:\Lakes\Screen View\Palo Alto_Construction_PS RWQCP.scr

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	AREA
EMISSION RATE (G/(S-M**2))	=	0.211575E-04
SOURCE HEIGHT (M)	=	4.5000
LENGTH OF LARGER SIDE (M)	=	12.8016
LENGTH OF SMALLER SIDE (M)	=	12.1920
RECEPTOR HEIGHT (M)	=	1.5000
URBAN/RURAL OPTION	=	URBAN

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = 0.000 M**4/S**3; MOM. FLUX = 0.000 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	MAX DIR (DEG)
2.	3.532	1	1.0	1.0	320.0	4.50	42.
100.	10.22	5	1.0	1.0	10000.0	4.50	11.
200.	3.299	5	1.0	1.0	10000.0	4.50	1.
300.	1.635	5	1.0	1.0	10000.0	4.50	1.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 2. M:

35.	22.55	4	1.0	1.0	10000.0	4.50	39.

****
*** SUMMARY OF SCREEN MODEL RESULTS ***
****

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	22.55	35.	0.

```
12/04/14
08:06:38
  ***  SCREEN3 MODEL RUN  ***
  *** VERSION DATED 96043 ***
C:\Lakes\Screen View\Palo Alto_Construction_PS Soccer.scr

 SIMPLE TERRAIN INPUTS:
    SOURCE TYPE                  =        AREA
    EMISSION RATE (G/(S-M**2))   =    0.349913E-04
    SOURCE HEIGHT (M)            =      4.5000
    LENGTH OF LARGER SIDE (M)    =     15.2400
    LENGTH OF SMALLER SIDE (M)   =      9.1440
    RECEPTOR HEIGHT (M)          =      1.5000
    URBAN/RURAL OPTION           =       URBAN
 THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
 THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS
ENTERED.

    MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION


 BUOY. FLUX =    0.000 M**4/S**3;  MOM. FLUX =    0.000 M**4/S**2.

 *** FULL METEOROLOGY ***

 **********************************
 *** SCREEN AUTOMATED DISTANCES ***
 **********************************

 *** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING
DISTANCES ***

   DIST     CONC             U10M   USTK  MIX HT   PLUME  MAX DIR
    (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   (DEG)
 -------  ----------  ----  -----  -----  ------  ------  -------
      2.   6.903        1     1.0    1.0   320.0    4.50      2.
    100.   15.45        5     1.0    1.0 10000.0    4.50      0.
    200.   4.903        5     1.0    1.0 10000.0    4.50      2.
    300.   2.418        5     1.0    1.0 10000.0    4.50      4.

 MAXIMUM 1-HR CONCENTRATION AT OR BEYOND     2. M:
     35.   37.28        4     1.0    1.0 10000.0    4.50      0.

      ***************************************
      *** SUMMARY OF SCREEN MODEL RESULTS ***
      ***************************************

  CALCULATION        MAX CONC    DIST TO   TERRAIN
   PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
 --------------   -----------   -------   -------
 SIMPLE TERRAIN      37.28          35.        0.
```

SCREEN3 Model Results

	PM2.5 (lbs/hr/sqft)	Source Release Height (ft)	Larger Side Length (ft)	Smaller Side Length (ft)	Search Through a Range of Wind Directions	Meteorology	1 Hour Maximum Air Concentration ($\mu g/m^3$)	Dose (mg/kg-day)	Cancer Risk (potential chances per 1 million)
Pipeline - 2 Crews	0.0000506	10	300	30	Y	Full Meteorology	535.3	0.0426	0.469
Pipeline - HDD 2 Crews	0.0000160	10	33.162	33.162	Y	Full Meteorology	36.93	0.0029	0.032
Pump Station - Soccer Field	0.0000258	10	50	30	Y	Full Meteorology	78.95	0.0031	0.035
Pump Station - RWQCP	0.0000156	10	42	40	Y	Full Meteorology	46.78	0.0019	0.020

Appendix J – Biological Resources Assessment

FINAL

Palo Alto Recycled Water Project Final Biological Resources Assessment

Prepared for:
RMC Water and Environment
222 Sutter Street, Suite 700
San Francisco, CA 94108
Attn: Suet Chau

Prepared on behalf of:
The City of Palo Alto

Prepared by:
MIG, Inc.

Date:
April 10, 2014

Project Number:
06-27367A

MIG

FINAL

Contents

FINAL

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List of Abbreviated Terms

AMM	Avoidance and Minimization Measures
BMP	Best Management Practice
BRA	Biological Resources Assessment
BUOW	Burrowing Owl
CCR	California Clapper Rail
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CFP	California Fully Protected Species
CFR	Code of Federal Regulations
City	City of Palo Alto
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CRLF	California Red-legged Frog
CSSC	California Species of Special Concern
CWA	Clean Water Act
ENVIRON	ENVIRON International Corporation
ESD	Environmental Services Division
FESA	Federal Endangered Species Act
HCP	Habitat Conservation Plan
HDD	Horizontal Directional Drilling
LSAA	Lake and Streambed Alteration Agreement
MBTA	Migratory Bird Treaty Act
NCCP	Natural Community Conservation Plan
NOAA Fisheries Service	National Oceanic and Atmospheric Administrations' National Marine Fisheries Service
NOHA	Northern Harrier
NPPA	Native Plant Protection Act
NRCS	Natural Resource Conservation Service
NWI	National Wetland Inventory
PUE	Public Utility Easement
RWQCB	Regional Water Quality Control Board
RWQCP	Regional Water Quality Control Plant
SMCY	Saltmarsh Common Yellowthroat
SR	State Route
SWPPP	Storm Water Pollution Prevention Plan
UFMP	Urban Forest Master Plan
U.S.	United States
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency

USFWS	United States Fish and Wildlife Service
USGS	United Stated Geological Survey

1 Introduction

This report presents the results of ENVIRON International Corporation (ENVIRON) and MIG Inc.'s (MIG) biological resources assessment (BRA) for Phase 3 of the proposed Palo Alto Recycled Water Project (project) located within the City of Palo Alto in Santa Clara County, California (Figure 1). The project consists of an approximately five-mile-long backbone pipeline and lateral pipeline connections, a booster pump, and pump facility locations. The purpose of this assessment is to identify potential sensitive biological resources within the project alignment and vicinity and identify potential impacts to these resources resulting from construction and operation of the project. This report provides (1) a description of the physical characteristics of the project area, (2) an account of vegetation communities and associated wildlife habitats present within the project area, (3) a discussion of special-status plant and animal species and sensitive communities that are known to occur or that could potentially occur within the project area, (4) an evaluation of the potential impacts to biological resources that may occur as a result of the project, and (5) recommendations to avoid or minimize the significance of those impacts. The evaluation of potential project impacts is consistent with the biological resources thresholds of significance in Appendix G of the California Environmental Quality Act (CEQA) Guidelines.

The project is the next phase of the Palo Alto Wastewater Reclamation Program. This program is a multi-phased program to facilitate the increased use of reclaimed water as a replacement for potable water and to reduce the discharge of treated wastewater from the Palo Alto Regional Water Quality Control Plant (RWQCP). The proposed project would increase the service area of the RWQCP's recycled water system to initially include the City of Palo Alto to the Stanford Research Park Area. Future extensions could serve Stanford University and Los Altos Hills, as well as providing a loop by making a second connection to the Phase 2 Mountain View Project.

1.1 Regional and Local Setting

The proposed project will involve construction of approximately 5 miles of pipeline backbone (with pipes ranging from 12 to 18 inches in diameter) and lateral pipelines, an up to 1,500 square-foot booster pump station, and a 1,600 square-foot pump station at the RWQCP. The RWQCP is located at 2501 Embarcadero Way, Palo Alto, CA 94303-3326.

The pipeline alignment consists of a preferred alignment and two alternative alignment options. All pipeline alignments would be located in urban areas, along existing rights-of-way using trenchless construction techniques (i.e., attaching to the side of existing structures, installing in roadways or bridges, or micro tunneling) (Figure 1). Three creeks will be crossed by the proposed alignment, alternative alignment options, and lateral pipelines (i.e., Adobe Creek, Barron Creek, and Matadero Creek). The pipeline will be installed at all of these crossings using trenchless construction methods.

The project area lies within two different flood zones: Zone AE and Zone X. The majority of the project area is located within Zone X. However, the northeast part of the project area between Middlefield Road and US-101, including the proposed RWQCP pump station as well as the RWQCP facility, are located within Zone AE. Zone X is defined as an area of moderate risk of flooding (within the 100- and 500-year flood limits). Zone AE, where the 100-year flood will be less than a foot deep. Zone AE is defined as an area where elevation of the base flood (i.e., 100-year flood level) has been determined by FEMA to be 8 feet above mean sea level.

The elevations within the proposed project area range from approximately sea level to 230 feet above mean sea level. Annual average precipitation for the proposed project is approximately 16 inches per year, with the majority of precipitation falling between November and March.

1.2 Project Summary

The proposed pipeline consists of the backbone pipeline and offshoots, or lateral pipelines (Figure 1). The proposed backbone pipeline alignment would begin with a connection point to the Mountain View Project near the intersection of East Bayshore Road and Corporation Way. The pipeline would be constructed using trenchless techniques under US-101, and would run along Fabian Way to East Meadow Drive where it would cross Adobe Creek. The pipeline would run along East Meadow Drive across Middlefield Road, and then continue along East Meadow Drive, Cowper Street, and El Dorado Avenue to Alma Street, along Alma Street to Page Mill Road, and along Page Mill Road to El Camino Real. The pipeline would continue across El Camino Real, along Page Mill Road to Hanover Street, and along Hanover Street and Hillview Avenue to Arastradero Road.

Two alternative pipeline alignment options would potentially replace segments of the proposed backbone pipeline alignment depending on constructability and design considerations. Pipeline Alignment Option 1 would start from the new connection point to the Mountain View Project at the intersection of US-101 and Adobe Creek, and would run along Adobe Creek. The pipeline would cross Adobe Creek on an existing bridge where it would run along West Bayshore Road and connect to the proposed pipeline alignment at Fabian Way. This option would replace the proposed pipeline alignment from the proposed East Bayshore Road and Corporation Way connection to Fabian Way.

Pipeline Alignment Option 2 would begin at the proposed alignment at the corner of Page Mill Road and El Camino Real. The pipeline would connect to Hansen Way through the Palo Alto Square parking lot. The pipeline would run along Hansen Way and use an existing utility easement as a ROW through the parking lot connecting Hansen Way and Hanover Street.

The proposed booster pump station would be located at 2700 El Camino Real, near the southeast corner of Page Mill Road and El Camino Real intersection at the Mayfield Soccer Fields, within a parking area. It will be constructed underground due to the prominent visual location and to avoid impacts to the existing park uses.

Construction of the proposed RWQCP pump station would occur completely within the existing physical footprint of the RWQCP. However, a connection pipeline may also be constructed (depending on the option selected) to connect this pump station to an existing pipeline that connects to the proposed pipeline at Corporation Way. This connection pipeline would be constructed using open trench construction or horizontal directional drilling (HDD) or microtunneling.

Construction of the proposed pipeline could occur either via open trench construction or horizontal directional drilling (HDD).

Three creeks would be crossed by the preferred and alternative alignments, and pipeline laterals (i.e., Adobe Creek, Barron Creek, and Matadero Creek). Adobe Creek and Barron Creek are concrete lined channels. Matadero creek is a natural bottom channel with concrete box culverts at its road crossings. Creek crossings would be constructed as follows:

- **Adobe Creek at East Meadow Drive:** The pipeline would be attached to the south side of the bridge or installed in the roadway on the bridge.
- **Adobe Creek at US101:** This is a crossing associated with the Option 1 alignment where the existing Adobe Creek crosses under US-101. The pipeline would be hung on the south side of the existing bridge.
- **Adobe Creek at Middlefield Road (lateral):** This lateral pipeline crossing would be a smaller pipe than the backbone pipeline. It will be hung from the bridge or installed in the roadway on the bridge.
- **Barron Creek at Cowper Street**: The pipeline would be attached to the downstream side of the Cowper Street Bridge or installed in the roadway on the bridge.
- **Barron Creek at Miranda Ave (lateral):** The lateral pipeline would be constructed at Miranda Avenue using trenchless techniques.
- **Matadero Creek at Cowper Street**: The pipeline would be attached to the downstream side of the bridge or installed in the roadway on the bridge.
- **Matadero Creek at Hillview Ave:** The pipeline would be installed in the roadway, above the 12-foot wide box culvert.

HDD could also be employed at any of the above crossings. In addition to the creek crossings, a trenchless railroad crossing would occur on Page Mill Road between Alma Street and Park Boulevard. Another trenchless crossing may occur on Hillview Avenue at the intersection of Foothill Expressway to cross a San Francisco Public Utilities Commission (SFPUC) ROW. Trenchless construction may also be used to cross busy intersections at Page Mill Road and El Camino Real, and Hillview Avenue and Foothill Expressway.

2 Regulatory Setting

The following discussion identifies federal, state, and local environmental regulations that serve to protect sensitive biological resources relevant to the proposed Project and California Environmental Quality Act (CEQA) review process.

2.1 Federal

2.1.1 Federal Endangered Species Act

The Federal Endangered Species Act (FESA) of 1973, as amended, provides the regulatory framework for the protection of plant and animal species (and their associated critical habitats), which are formally listed, proposed for listing, or candidates for listing as endangered or threatened under the FESA. The FESA has the following four major components: (1) provisions for listing species, (2) requirements for consultation with the United States (U.S.) Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries Service), (3) prohibitions against "taking" (i.e., harassing, harming, hunting, shooting, wounding, killing, trapping, capturing, or collecting, or attempting to engage in any such conduct) of listed species, and (4) provisions for permits that allow incidental "take". The FESA also discusses recovery plans and the designation of critical habitat for listed species. Both the USFWS and the NOAA Fisheries Service share the responsibility for administration of the FESA. During the CEQA review process, each agency is given the opportunity to comment on the potential of the proposed Project to affect plants and animals listed, proposed for listing, or candidate for listing.

2.1.2 The Migratory Bird Treaty Act

The Federal Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703 et seq.), Title 50 Code of Federal Regulations (CFR) Part 10, prohibits taking, killing, possessing, transporting, and importing of migratory birds, parts of migratory birds, and their eggs and nests, except when specifically authorized by the Department of the Interior. As used in the act, the term "take" is defined as meaning, "to pursue, hunt, capture, collect, kill or attempt to pursue, hunt, shoot, capture, collect or kill, unless the context otherwise requires." With a few exceptions, most birds are considered migratory under the MBTA. Disturbances that causes nest abandonment and/or loss of reproductive effort or loss of habitat upon which these birds depend would be in violation of the MBTA.

2.1.3 Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act that was first passed in 1940. It regulates take, possession, sale, purchase, barter, transport, import and export of any bald or golden eagle or their parts (e.g., nests, eggs, young) unless allowed by permit (16 U.S.C. 668(a); 50 CFR 22). Take was broadly defined to include shoot, wound, kill, capture, collect, molest, or disturb. In the 1972 amendments, penalties for violations were raised to a maximum of fine $250,000 for an individual or a maximum of two years in prison for a felony conviction, with a doubling for organizations instead of individuals.

2.1.4 Clean Water Act Sections 404 and 401

The U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA) regulate the discharge of dredged or fill material into waters of the U.S., including wetlands, under Section 404 of the Clean Water Act (CWA) (33 USC 1344). Waters of the U.S. are defined in Title 33 CFR Part 328.3(a) and include a range of wet environments such as lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds. The lateral limits of jurisdiction in those waters may be divided into three categories – territorial seas, tidal waters, and non-tidal waters – and is determined depending on which type of waters is present (Title 33 CFR Part 328.4(a), (b), (c)). Activities in waters of the U.S. regulated under Section 404 include fill for development, water resource projects (e.g., dams and levees), infrastructure developments (e.g., highways, rail lines, and airports) and mining projects. Section 404 of the CWA requires a federal permit before dredged or fill material may be discharged into waters of the U.S., unless the activity is exempt from Section 404 regulation (e.g., certain maintenance, farming, and forestry activities).

Section 401 of the CWA (33 U.S. Code (U.S.C.) 1341) requires an applicant for a federal license or permit to conduct any activity that may result in a discharge of a pollutant into waters of the U.S. to obtain a Water Quality Certification from the state in which the discharge originates The discharge cannot occur unless it meets applicable water quality standards. A Water Quality Certification obtained for the construction of any facility will also apply to the subsequent operation of the facility. The responsibility for the protection of water quality in California rests with the State Water Resources Control Board (State Water Board) and its nine Regional Water Quality Control Boards (RWQCBs).

2.1.5 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 U.S.C. Sections 661-667e, March 10, 1994, as amended 1946, 1958, 1978, and 1995) requires that whenever waters or channel of a stream or other body of water are proposed or authorized to be modified by a public or private agency under a federal license or permit, the federal agency must first consult with the USFWS and/or NOAA Fisheries Service and with the head of the agency exercising administration over the wildlife resources of the state where construction will occur (in this case the California Department of Fish and Wildlife [CDFW]), with a view to conservation of birds, fish, mammals and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent.

2.2 State

2.2.1 California Endangered Species Act

The State of California enacted similar laws to the FESA and the California Native Plant Protection Act (NPPA) in 1977. The California Endangered Species Act (CESA) enacted in 1984. The CESA expanded upon the original NPPA and enhanced legal protection for plants, but the NPPA remains part of the California Fish and Game Code. To align with the FESA, CESA created the categories of “threatened” and “endangered” species. It converted all “rare” animals into the CESA as threatened species, but did not do so for rare plants. Thus, these laws provide the legal framework for protection of California-listed rare, threatened, and endangered plant and animal species. The CDFW implements the NPPA and CESA, and its Wildlife and Habitat Data Analysis Branch maintains the California Natural Diversity Database (CNDDB), a computerized inventory of information on the general location and status of California's rarest plants, animals, and natural communities. During the CEQA review process, the CDFW is given the opportunity to comment on the potential of a proposed project to affect listed plants and animals.

2.2.2 Native Plant Protection Act

The NPPA of 1977 (California Fish and Game Code, §§ 1900 through 1913) directed the CDFW to carry out the Legislature's intent to "preserve, protect and enhance rare and endangered plants in this State." The NPPA is administered by the CDFW, which has the authority to designate native plants as endangered or rare and to protect them from "take."

2.2.3 California Environmental Quality Act

CEQA was enacted in 1970 to provide for full disclosure of environmental impacts to the public before issuance of a permit by state and local public agencies. CEQA (Public Resources Code Sections 21000 et. seq.) requires public agencies to review activities which may affect the quality of the environment so that consideration is given to preventing damage to the environment. When a lead agency issues a permit for development that could affect the environment, it must disclose the potential environmental effects of the project. This is done with an "Initial Study and Negative Declaration" (or Mitigated Negative Declaration) or with an "Environmental Impact Report". Certain classes of projects are exempt from detailed analysis under CEQA. CEQA Guidelines Section 15380 defines endangered, threatened, and rare species for purposes of CEQA and clarifies that CEQA review extends to other species that are not formally listed under the state or federal ESAs but that meet specified criteria.

2.2.4 Fully Protected Species and Species of Special Concern

The classification of California fully protected (CFP) species was the CDFW's initial effort to identify and provide additional protection to those animals that were rare or faced possible extinction. Lists were created for fish, amphibian and reptiles, birds, and mammals. Most of the species on these lists have subsequently been listed under CESA and/or FESA. The Fish and Game Code sections (§5515 for fish, §5050 for amphibian and reptiles, §3511 for birds, §4700 for mammals) deal with CFP species and state that these species "…may not be taken or possessed at any time and no provision of this code or any other law shall be construed to authorize the issuance of permits or licenses to take any fully protected species" (CDFW Fish and Game Commission 1998). "Take" of these species may be authorized for necessary scientific research. This language makes the CFP designation the strongest and most restrictive regarding the "take" of these species. In 2003, the code sections dealing with CFP species were amended to allow the CDFW to authorize take resulting from recovery activities for state-listed species.

California species of special concern (CSSC) are broadly defined as animals not listed under the FESA or CESA, but which are nonetheless of concern to the CDFW because they are declining at a rate that could result in listing or historically occurred in low numbers and known threats to their persistence currently exist. This designation is intended to result in special consideration for these animals by the CDFW, land managers, consulting biologists, and others, and is intended to focus attention on the species to help avert the need for costly listing under FESA and CESA and cumbersome recovery efforts that might ultimately be required. This designation also is intended to stimulate collection of additional information on the biology, distribution, and status of poorly known at-risk species, and focus research and management attention on them. Although these species generally have no special legal status, they are given special consideration under the CEQA during project review.

2.2.5 California Fish and Game Code Sections 3503 and 3513

According to Section 3503 of the California Fish and Game Code, it is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird (except English sparrow (*Passer domesticus*) and European Starling (*Sturnus vulgaris*)). Section 3503.5 specifically protects birds in the orders Falconiformes and Strigiformes (birds-of-prey) from “take”. Section 3513 essentially overlaps with the MBTA, prohibiting the “take” or possession of any migratory non-game bird. Disturbance that causes nest abandonment and/or loss of reproductive effort is considered “take” by the CDFW.

2.2.6 Other Sensitive Plants – California Native Plant Society

The California Native Plant Society (CNPS) is a non-profit plant conservation organization that publishes and maintains an Inventory of Rare and Endangered Vascular Plants of California in both hard copy and electronic version (http://www.rareplants.cnps.org/).

The Inventory assigns plants to the following categories:

- 1A Presumed extinct in California;
- 1B Rare, threatened, or endangered in California and elsewhere;
- 2 Rare, threatened, or endangered in California, but more common elsewhere;
- 3 Plants for which more information is needed – A review list; and
- 4 Plants of limited distribution – A watch list.

Additional endangerment codes are assigned to each taxon as follows:

- 1 Seriously endangered in California (over 80% of occurrences threatened/high degree of immediacy of threat).
- 2 Fairly endangered in California (20-80% occurrences threatened).
- 3 Not very endangered in California (<20% of occurrences threatened or no current threats known).

Plants that are Rank 1A, 1B, and 2 of the CNPS Inventory consist of plants that may qualify for listing by the CDFW, as well as other state agencies (e.g., California Department of Forestry and Fire Protection). As part of the CEQA process, such species should be fully considered, as they meet the definition of threatened or endangered under the NPPA and Sections 2062 and 2067 of the California Fish and Game Code. California Rare Plant Rank 3 and 4 species are considered to be plants about which more information is needed or are uncommon enough that their status should be regularly monitored. Such plants may be eligible or may become eligible for state listing, and CNPS and CDFW recommend that these species be evaluated for consideration during the preparation of CEQA documents.

2.2.7 Porter-Cologne Water Quality Control Act

Waters of the State are defined by the Porter-Cologne Act as "any surface water or groundwater, including saline waters, within the boundaries of the state." The State Water Board protects all waters in its regulatory scope, but has special responsibility for isolated wetlands and headwaters. These water bodies have high resource value, are vulnerable to filling, and may not be regulated by other programs, such as Section 404 of the CWA. Waters of the State are regulated by the State Water Board under the State Water Quality Certification Program, which regulates discharges of dredged and fill material under Section 401 of the CWA and the Porter-Cologne Water Quality Control Act. Projects that require a USACE permit, or fall under other federal jurisdiction, and have the potential to impact Waters of the State are required to comply with the terms of the Water Quality Certification Program. If a proposed project does not require a federal license or permit, but does involve activities that may result in a discharge of harmful substances to Waters of the State, the State Water Board has the option to regulate such activities under its state authority in the form of Waste Discharge Requirements or Certification of Waste Discharge Requirements.

2.2.8 California Fish and Game Code Section 1600-1603

Streams, lakes, and riparian vegetation are subject to jurisdiction by the CDFW under Sections 1600-1616 of the California Fish and Game Code. Any activity that will do one or more of the following: (1) substantially obstruct or divert the natural flow of a river, stream, or lake; (2) substantially change or use any material from the bed, channel, or bank of a river, stream, or lake; or (3) deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into a river, stream, or lake generally require a 1602 Lake and Streambed Alteration Agreement (LSAA). The term "stream", which includes creeks and rivers, is defined in the California Code of Regulations (CCR) as follows: "a body of water that flows at least periodically or intermittently through a bed or channel having banks and supports fish or other aquatic life". This includes watercourses having a surface or subsurface flow that supports or has supported riparian vegetation" (14 CCR 1.72). In addition, the term stream can include ephemeral streams, dry washes, watercourses with subsurface flows, canals, aqueducts, irrigation ditches, and other means of water conveyance if they support aquatic life, riparian vegetation, or stream-dependent terrestrial wildlife (CDFW Environmental Services Division (ESD) 1994). Riparian is defined as "on, or pertaining to, the banks of a stream"; therefore, riparian vegetation is defined as, "vegetation which occurs in and/or adjacent to a stream and is dependent on, and occurs because of, the stream itself" (CDFW ESD 1994). Removal of riparian vegetation also requires a Section 1602 LSAA from the CDFW.

2.2.9 Sensitive Vegetation Communities

Sensitive vegetation communities are natural communities and habitats that are either unique in constituent components, of relatively limited distribution in the region, or of particularly high wildlife value. These communities may or may not necessarily contain special-status species. Sensitive natural communities are usually identified in local or regional plans, policies or regulations, or by the CDFW (i.e., CNDDB) or the USFWS. The CNDDB identifies a number of natural communities as rare, which are given the highest inventory priority (Holland 1986; CDFW 2014). Impacts to sensitive natural communities and habitats must be considered and evaluated under the CEQA (CCR: Title 14, Div. 6, Chap. 3, Appendix G).

2.3 Local

2.3.1 City of Palo Alto Comprehensive Plan

The Natural Environment Element of the City of Palo Alto (City) Comprehensive Plan (2007), combined with other Comprehensive Plan Update Elements, defines certain goals and policies for the conservation of sensitive natural resources. The Comprehensive Plan is in the process of being amended to ensure that it is effective through the year 2020. The amended plan has not yet been adopted, so the goals and policies of the 2007 Plan that are relevant to the propose project are described below.

Goals

N-1 A citywide open space system that protects and conserves Palo Alto's natural resources and provides a source of beauty and enjoyment for Palo Alto residents.

N-2 Conservation of creeks and riparian areas as open space amenities, natural habitat areas, and elements of community design.

N-3 A thriving "urban forest" that provides ecological, economic, and aesthetic benefits for Palo Alto.

N-4 Water resources that are prudently managed to sustain plant and animal life, support urban activities, and protect public health and safety.

Policies

N-3: Protect sensitive plant species resources from the impacts of development.

N-7: Preserve and protect the Bay, marshlands, salt ponds, sloughs, creeks, and other natural water or wetland areas as open space.

N-9: Avoid fencing, piping, and channelization of creeks when flood control and public safety can be achieved through measures that preserve the natural environment and habitat of the creek.

N-11: Preserve the integrity of riparian corridors.

N-12: Preserve the habitat value of creek corridors through the preservation of native plants and the replacement of invasive, non-native plants with native plants.

N-13: Discourage creek bank instability, erosion, downstream sedimentation, and flooding by minimizing site disturbance and vegetation removal on or near creeks and carefully reviewing grading and drainage plans for development near creeks and elsewhere in the watersheds of creeks.

N-17: Preserve and protect heritage trees, including native oaks and other significant trees, on public and private property.

N-18: Protect Palo Alto's groundwater from the adverse impacts of urban uses.

N-19: Secure a reliable, long-term supply of water for Palo Alto.

N-21: Reduce non-point source pollution in urban runoff from residential, commercial, industrial, municipal, and transportation land uses and activities.

N-23: Reduce the discharge of toxic materials into the City's sanitary sewer collections by promoting use of Best Management Practices.

2.3.1 Palo Alto Tree Preservation Ordinance

Chapter 8 of the City's Municipal Code regulated trees and tree protection in Palo Alto. The following chapters describe the City's tree regulation policies:

Title 8 Trees and Vegetation, Chapter 8.10 Tree Preservation and Management Regulation - Chapter 8.10 protects specified trees in the City and establishes a standard for removal, maintenance and planting of trees in the City, with the goal of preserving the City's trees. Chapter 8.10 provides rules for the protection of trees, designation of heritage trees, and for when trees can be removed.

Title 22 Parks, Chapter 22.04 Parks and Recreation Building Use and Regulations – Chapter 22.04 establishes guidelines for the protection of flora and fauna in City parks and open space by prohibiting the removal or injury to plants, trees, or wildlife in the parks without written consent of the director unless authorized by park regulations.

2.3.1 City of Palo Alto Urban Forest Master Plan

The City has proposed a range of plans and policies aimed at maintaining, protecting, and enhancing the urban forest. The management plans and programs for trees in the City consist of the new Urban Forest Master Plan (UFMP), the Street Tree Management Plan, and the Line Clearing and Right Tree, Right Place Programs. The UFMP establishes long-term management goals and strategies to foster a sustainable urban forest in the City. The UFMP addresses topics such as the state of the City's tree canopy, best management practices, interdepartmental coordination, and tree-related City regulations. At the time of this report, the UFMP was still a Draft document awaiting adoption by the City.

2.3.2 Stanford University Habitat Conservation Plan

Portions of the proposed project are within the Stanford University Habitat Conservation Plan (HCP) area. Stanford University prepared an HCP to address protection and management of four federally listed, and one special-status, species that occur/potentially occur on Stanford lands. These species are the California tiger salamander, California red-legged frog, San Francisco garter snake, steelhead, and western pond turtle. They are also known as the Covered Species. The HCP includes measures to minimize the impacts of University activities on federally protected species and protect and enhance habitat on Stanford lands. The HCP was a required element for the University's application to the USFWS and NOAA Fisheries for Incidental Take Permits (ITPs) under the FESA. The ITPs authorize take of federally listed species caused by otherwise lawful activities, such as those associated with normal operation of the University. These are also known as the Covered Activities, and they are specifically described in the HCP.

The Plan Area identified in the HCP includes some lands that fall within the City of Palo Alto limits (e.g., Page Mill Road west of El Camino Real, lands along San Francisquito Creek), and lands that fall within the City of Palo Alto's Sphere of Influence (e.g., lands west of Junipero Serra Boulevard). The HCP includes the following biological goals:

Biological Goal #1: Maintain and enhance natural communities so that they benefit the Covered Species.

Biological Goal #2: Stabilize the local California tiger salamander population and increase its chance of long-term persistence at Stanford.

Biological Goal #3: Maintain ponds to promote California tiger salamander reproduction in the Foothills.

Biological Goal #4: Increase the local California red-legged frog population and increase its chance of long-term persistence at Stanford.

Biological Goal #5: Maintain or improve hydrologic and terrestrial conditions that presently support steelhead and increase the chance of long-term persistence for the local steelhead population.

Biological Goal #6: Maintain and improve habitat for western pond turtle to increase its chance of long-term persistence at Stanford.

Biological Goal #7: Maintain or improve habitat that could support the San Francisco garter snake and continue to contribute to the body of information about garter snakes at Stanford.

The broad Biological Goals are supported by more specific Biological Objectives that provide measurable ways of determining whether a goal is being met. The goals and objectives provide the framework for the conservation program described in the HCP and identify specific management and minimization actions.

3 Methods

The analysis of potential biological resources impacts associated with the development and operation of the proposed project involved a review of available background information pertaining to biological resources on and in the vicinity of the project area and completion of multiple field surveys. The methods of the background review and field surveys are summarized below. The specific methods used to assess the existing conditions of the project area described in Section 4.0 (Existing Conditions) (i.e., assessment of the plant communities and wildlife habitats and their potential to support special-status species and sensitive natural communities) are described below.

3.1 Literature Review

Prior to conducting field surveys, available background information pertaining to the biological resources on and in the vicinity of the project alignment proposed for development of the project was reviewed. Available literature and resource mapping reviewed included the occurrence records for special-status species and sensitive natural communities; past environmental studies for the site and vicinity; and numerous other information sources listed below:

- CDFW's California Natural Diversity Database (CNDDB) record search of the Cupertino, La Honda, Milpitas, Mindego Hill, Mountain View, Newark, Niles, Palo Alto, Redwood Point, San Jose West, San Mateo, and Woodside U.S. Geological Survey (USGS) 7.5-Minute Quadrangles (CDFW 2014);
- CNPS Electronic Inventory search of the Cupertino, La Honda, Milpitas, Mindego Hill, Mountain View, Newark, Niles, Palo Alto, Redwood Point, San Jose West, San Mateo, and Woodside USGS 7.5-Minute Quadrangles (CNPS 2010, CNPS 2014);
- USFWS's list of Federal Endangered and Threatened Species that occur in or may be affected by projects in Santa Clara County (USFWS 2014);
- U.S. Department of Agricultural (USDA) Natural Resource Conservation Service (NRCS) web soil survey (USDA NRCS 2014);
- USFWS's National Wetlands Inventory (NWI 2014b) for Santa Clara County;
- The Jepson Manual: Vascular Plants of California, Second Edition (Baldwin et al. 2012);
- The City of Palo Alto Comprehensive Plan (City of Palo Alto); and
- The Stanford University HCP (Stanford University 2013).

3.2 Field Surveys

Reconnaissance-level general biological resources surveys were conducted along the proposed 5-mile pipeline route at each of the nine proposed stream crossings and at the two proposed pump locations. Former ENVIRON Senior Biologist Laura Moran conducted the general biological resources surveys on May 20, 2011. The purpose of the general biological resources survey was to assess the existing conditions of the project, including characterizing and delineating the vegetation communities and associated wildlife habitats and evaluating the potential for these habitats to support special-status species and sensitive communities. The proposed pipeline route was driven and all proposed stream crossings were traversed by foot along public right-of-way. Ms. Moran met with RWQCP Manager Jamie Allen and toured the RWQCP physical plant and perimeter areas, including the proposed location of the pump station and tie-in to Embarcadero Road. In addition, Ms. Moran met with Julie Weiss who provided a plan set and explanation of the RWQCP Landscape Project. Due to project delays, an additional general biological resource survey was conducted by MIG biologists Laura Moran and Lauren Huff on November 5, 2014. The purpose of this general biological survey was to confirm that biological conditions (e.g., vegetation communities) along the proposed project alignment and at the RWQCP had not changed appreciably since the survey conducted in 2011. The proposed pipeline route was driven and all proposed stream crossings were traversed by foot along public right-of-way. The biologists also traversed the perimeter of the RWQCP by foot.

3.2.1 Plant Communities and Wildlife Habitats

Plant communities were classified based on existing descriptions developed Preliminary Descriptions of the Terrestrial Natural Communities of California (Holland 1986). However, in some cases it is necessary to identify variants of plant community types or to describe non-vegetated areas that are not described in the literature.

3.2.2 Sensitive Habitats and Aquatic Features

Habitats were assessed to determine if any wetlands and “waters” potentially subject to jurisdiction by the USACE, RWQCB, or CDFW were present. The project area was inspected for the presence of wetlands, drainages, streams, and other aquatic features, including those that support stream-dependent (riparian) plant species. In addition, plant communities were evaluated to determine if they are considered sensitive under federal or state regulations or policies.

3.2.3 Special-Status Species Habitat Evaluation

During general biological resources surveys, biologists evaluated the suitability of all vegetation communities to support special-status species documented in and within the vicinity of the project area. For the purposes of this assessment, special-status species include those plant and animals listed, proposed for listing or candidates for listing as threatened or endangered by the USFWS or NOAA Fisheries Service under the FESA, those listed or proposed for listing as rare, threatened or endangered by the CDFW under the CESA, animals designated as CFP or CSSC by the CDFW, birds protected by the USFWS under the MTBA and/or by the CDFW under Fish and Game Code Sections 3503 and 3513, and plants listed as Rank 1A, 1B, and 2 of the CNPS Inventory.

The potential occurrence of special-status plant and animal species within the project area was initially evaluated by developing a list of special-status species that are known to or have the potential to occur in the vicinity of the project area based on a review of past studies; search of current database records (e.g., CNDDB and CNPS Electronic Inventory records); and review of the USFWS list of federal endangered and threatened species. The potential for occurrence of those species included on the list were then evaluated based on the habitat requirements of each species relative to the conditions observed during the multiple biological surveys. Each species was evaluated for its potential to occur on or in the immediate vicinity of the project area according to the following criteria:

> *Not Expected:* There is no suitable habitat present within the project area (i.e., habitats within the project area are clearly unsuitable for the species requirements [e.g., foraging, breeding, cover, substrate, elevation, hydrology, plant community, disturbance regime, etc.]). The species has an extremely low probability of being found within the project area.
>
> *Low Potential:* Limited suitable habitat is present within the project area (i.e., few of the habitat components meeting the species requirements are present and/or the majority of habitat within the project area is unsuitable or of very low quality). Additionally, there are no or few recent known records of occurrence in the vicinity of the project area. The species has a low probability of being found within the project area.
>
> *Moderate Potential*: Suitable habitat is present within the project area (i.e., some of the habitat components meeting the species requirements are present and/or the majority of the habitat within the project area is suitable or of marginal quality). Additionally, there are few or many recent known records of occurrences in the vicinity of the project area. The species has a moderate probability of being found within the project area.
>
> *High Potential:* Highly suitable habitat is present within the project area (i.e., all habitat components meeting the species requirements are present and/or all of the habitat on the project area is highly suitable or of high quality). Additionally, there are few or many recent known records of occurrences in the vicinity of the project area. This species has a high probability of being found within the project area.
>
> *Present or Assumed Present*. Species was observed within the project area during recent surveys or has a recorded observation in the CNDDB on or adjacent to the project area.

Appendix A presents the list of special-status animals and plants that have the potential to occur in the vicinity of the project area, their habitat requirements, and a ranking of potential for occurrence on the project area. A list of observed plant and wildlife species can be found in Appendix B.

4 Existing Conditions

The following provides a description of the physical characteristics, vegetation communities and associated wildlife habitats, wildlife movement corridors, sensitive natural communities, special-status species, jurisdictional wetlands, and other waters present or potentially present in the project vicinity. Representative photographs of the project area are included in Appendix C of this report.

4.1 Physical Characteristics

The site proposed for the installation of the new RWQCP pump station is completely within the existing footprint of the RWQCP, which consists of industrial uses (structures, buildings, etc.). There are existing irrigation lines throughout the vicinity of the proposed RWQCP project area that were installed for watering the landscaped trees and shrubs that were planted to visually screen the RWQCP from the traveling public on Embarcadero and Harbor roads. Vegetation within the area of temporary disturbance for placement of a pipe connection from the new pump station to the existing recycled water line in Embarcadero Road consists of ruderal (e.g. weedy) vegetation and eucalyptus (*Eucalyptus* sp.) trees and other ornamental vegetation planted to screen the RWQCP. This area is part of the RWQCP Landscape Project that the City of Palo Alto is undertaking, The Landscape Project seeks to remove invasive plants and enhance the landscape with native plants along Embarcadero Road.

The proposed booster pump station will be located at 2700 El Camino Real, near the southeast corner of the Page Mill Road and El Camino Real intersection at the Mayfield Soccer Fields (Figure 1).

The proposed backbone and lateral pipeline alignments will consist of approximately five miles of pipeline installed in a mostly urban area within existing roadways and roadway bridges. However, approximately 0.2-mile of lateral pipeline at the southern end of the project will be installed along an existing fenceline in pastureland habitat between Deer Creek Road and Hillview Avenue.

The USDA NRCS soil survey information was used to map soil units within the project area surrounding the creek crossings where potentially significant impacts resulting from construction could occur. They are provided as an aid to determine the presence/absence of wetlands and the suitability of habitat of potentially occurring species. Due to the urban setting of this project, soil units for the entire project area within paved portions of the project are not discussed. The creek crossings include Adobe Creek at US 101, Adobe Creek at East Meadow Drive, Adobe Creek at Middlefield Road, Adobe Creek at Arastradero Road, Barron Creek at Cowper Street, Barron Creek at Miranda Avenue, Matadero Creek at Cowper Street, and Matadero Creek at Hillview Avenue. The proposed construction methods and potential impacts to sensitive status plants, animals, and their habitats are discussed in detail in Section 5.2 of this document.

Soils mapped at the crossings listed above consist of Novato Clay 0-1 percent slopes, Urbanland-Embarcadero Complex 0-2 percent slopes, Urbanland-Hangerone Complex -0-2 percent slopes, Urbanland-Clear Lake Complex 0-2 percent slopes, and Urbanland-Cropley Clay 0-2 percent slopes. A more detailed description of each soil series follows:

- The Novato series consists of deep, very poorly drained soils that formed in alluvium deposited along the margin of bays. Novato soils are nearly level with slopes ranging from 2 to 10 feet in elevation. The climate is subhumid with warm and partially foggy summers and cool moist winters. Mean annual precipitation is 12 to 35 inches.

- The Embarcadero series consists of very deep, naturally poorly drained soils that are now artificially drained. These soils formed in alluvium from mixed rock sources and are found in basins near the edge of marshes. Embarcadero soils are found at elevations from 0 to 10 feet. The mean annual precipitation is 14 to 16 inches.

- The Hangerone soil series consists of very deep, poorly drained soils that formed in alluvium from mixed rock sources. These soils are found in basins at elevations from 0 to 219 feet. Mean annual precipitation is 14 to 16 inches.

- The Clear Lake series consists of very deep, poorly drained soils that formed in fine textured alluvium derived from sandstone and shale. Clear Lake soils are found in basins and swales of drainageways at elevations from 25 to 2,000 feet. The soils are found in a dry subhumid climate of relatively hot dry summers and cool moist winters. Mean annual precipitation ranges from 10 to 35 inches.

- The Cropley series consists of very deep, moderately well and well drained soils that formed in alluvium from mixed rock sources. Cropley soils are found on alluvial fans, floodplains, and in small basins at elevations from 10 to 2,100 feet. The soils are found in dry subhumid mesothermal climates with dry summers and cool moist winters. The mean annual precipitation ranges from 12 to 30 inches.

4.2 Plant Communities & Associated Wildlife Habitats

As described in Section 3.0 (Methods), the classification of plant communities was based on Terrestrial Natural Communities of California (Holland 1986), as they most closely matched the existing descriptions provided in this literature. However, in some cases it was necessary to identify variants of plant community types that do not match the descriptions in the literature; these descriptions are based the biologists' observations of the dominant plant species and the physical characteristics of the areas in which they grow.

The majority of the proposed project area consists of developed land. Additional vegetation communities—disturbed habitat, ornamental vegetation, creek, and pastureland—occur within the proposed project area. Vegetation and habitat type are prime factors in determining the suitability for use by certain wildlife species and the occurrence of certain plant species. The following subsections provide descriptions of each habitat type and/or vegetation community.

4.2.1 Developed Habitat

Developed land includes areas where permanent structures and/or pavement have been placed, which prevents the growth of vegetation, or where landscaping is cleared, tended, and maintained. Developed land occurs within the majority of the proposed project area.

4.2.2 Disturbed Habitat

Disturbed habitat includes land cleared of vegetation (e.g., dirt roads) or lands containing a preponderance of non-native plant species. This type of habitat can also include areas that are mowed or landscaped regularly and, thus, preclude the development of native vegetation communities. Disturbed habitat was observed along the paved roads in the proposed project area, as well as in discontinuous areas surrounding the RWQCP. The disturbed habitat within the proposed project area consists of little to no vegetation, although some non-native, ruderal (weedy) grasses, such as Harding grass (*Phalaris aquatica*), wild oat (*Avena fatua*), and Russian thistle (*Salsola soda*), were observed in these areas.

4.2.3 Ornamental Vegetation

Ornamental vegetation includes lands that have been planted with landscaping and are maintained on an ongoing basis. Such landscaping may include native and non-native plantings. However, these plantings have been installed as part of an ornamental landscape plan and do not naturally occur on site. At the proposed project area, ornamental vegetation occurs intermittently throughout the proposed project area at the RWQCP and along both the backbone pipeline and lateral pipeline routes. This vegetation is dominated by species such as English ivy (*Hedera helix*), eucalyptus (*Eucalyptus* sp.), redwood (*Sequoia sempervirens*), peppertree (*Schinus* sp.), and olive (*Olea europaea*).

4.2.4 Creek

Creeks are perennial and seasonal linear water features (i.e., features that flow year-round or throughout the wet season). Perennial and intermittent creeks, including Adobe Creek, Matadero Creek, and Barron Creek, occur within the proposed project area. The proposed project consists of seven creek crossings. Most of the creek crossings in the proposed project area are channelized and are maintained for flood control and storm water conveyance and support little to no vegetation. However, Matadero Creek near Hillview Avenue has a natural bottom channel. The banks of Matadero Creek near Hillview Avenue are vegetated by native and non-native trees, including redwoods.

4.2.5 Pastureland

Pastureland consists of grassland areas heavily grazed by domestic animals such as cattle and horses. As a result, the grasses remain short for the majority of the year. Pastureland in the proposed project area is located within the southern portion of the project area between Deer Creek Road and Hillview Avenue. Numerous ground squirrel burrows (*Otospermophilus beecheyi*) were observed scattered throughout the pastureland area. In addition, some serpentine bedrock outcrops and sparse coast live oak are present within the higher elevations of this habitat types. However, no coast live oak or serpentine outcrops are present directly adjacent to or in the immediate vicinity of the proposed pipeline alignment.

4.2.6 Sensitive Plant Communities

CDFW and CNPS have identified several native plant communities that are rare and unique to California. While they have no legal, protective status, impacts to these plant communities may be considered “significant” under CEQA. Sensitive plant communities identified by CDFW near the proposed project include Northern Coastal Salt Marsh, Valley Oak Woodland, and Serpentine Bunchgrass. No sensitive natural community types are present in or in the vicinity of the proposed project alignment. The Valley Oak Woodland and Serpentine Bunchgrass communities occur in the foothills south of Foothill Expressway and west of Arastradero Road. The Northern Coastal Salt Marsh occurs within the Baylands Preserve east of the proposed project.

4.3 Wildlife Movement Corridors

The movement and migration of wildlife species has been substantially altered due to habitat fragmentation over the past century. This fragmentation has most commonly been caused by development, which can result in large patches of land becoming inaccessible and forming a virtual barrier between undeveloped areas, or resulting in additional roads which, although narrow, may result in barriers to smaller or less mobile wildlife species. Habitat fragmentation results in isolated islands of habitat, which affects wildlife behavior, foraging activity, reproductive patterns, immigration and emigration or dispersal capabilities, and survivability.

Wildlife corridors play an important role in countering habitat fragmentation. A wildlife corridor is a linear landscape element which serves as a linkage between historically connected habitats or landscapes that are otherwise separated (McEuen 1993) and is meant to provide avenues along which wildlife can travel, migrate, and meet mates; plants can propagate; genetic interchange can occur; populations can move in response to environmental changes and natural disasters; and individuals can re-colonize habitats from which populations have been locally extirpated (Beir and Loe 1992). Corridors can consist of a sequence of stepping-stones across the landscape (i.e., discontinuous areas of habitat such as isolated wetlands and roadside vegetation), continuous lineal strips of vegetation and habitat (e.g., riparian strips and ridge lines), or they may be parts of larger habitat areas selected for its known or likely importance to local wildlife.

The marshland habitats adjacent to the project area in the vicinity of the RWQCP and the Los Altos foothills to the south of the proposed project area provide potential wildlife movement corridors. However, movement is unlikely in the project area due to the urban nature of the area and the numerous barriers to movement (e.g., pavement, buildings, walls). For these reasons, the project area pipeline alignment does not serve as a continuous regional connection for wildlife species. Limited wildlife movement may occur along the natural bottomed creeks (i.e., Matadero Creek) in the proposed project area. In addition, limited wildlife movement may occur within the project area alignment by urban adapted species trying to reach more high quality habitat to the south (i.e., foothills) and north (i.e., marshland).

4.4 Special-Status Plants and Animals

For the purposes of this assessment, special-status species include those plants and animals listed, proposed for listing, or candidates for listing as threatened or endangered by the USFWS or NOAAA Fisheries Service under the FESA; those listed or proposed for listing as rare, threatened or endangered by the CDFW under CESA; animals designated as CFP or CSSC by the CDFW; birds protected by the USFWS under the MBTA and/or by the CDFW under Fish and Game Code Sections 3503 and 3513; and plants listed as Rank 1A, 1B, and 2 of the CNPS Inventory.

4.4.1 Special-Status Plants

Based upon a review of species occurrence databases, it was determined that 47 special-status plant species have been documented in the vicinity of the project area. A table presenting all special-status plant species considered and evaluated for their potential occurrence within the project area, including species' habitat requirements and reported blooming periods, is provided in Appendix A. Based on a review of available databases and literature, and an assessment of the types of habitats within the project area, it was determined that none of the special-status plant species are expected to occur within the project area (i.e., all special-status plant species were ranked as “Not Expected” or “Low Potential”). This determination was made due to the absence of essential habitat requirements for the species, the absence of known occurrences within 5 miles of the project area, and/or project area elements are outside the species known distributional range.

4.5 Special-Status Animals

It was determined that 34 special-status animal species are known to or have the potential to occur in the vicinity of the project area. A table presenting all special-status animal species considered and evaluated for their potential occurrence within the project area, including species' habitat requirements, is provided in Appendix A. Of these animal species, 30 are not expected to occur within the project area (i.e., species ranked as "Not Expected" or "Low Potential"). Reasons include the absence of essential habitat requirements for the species, the distance to known occurrences and/or the species distributional range, the limited availability of foraging and breeding habitat, amount of site disturbance from past and present land uses, and/or the proximity of human-related disturbances. Based on biological surveys and habitat suitability analysis conducted by biologists in May 2011 and November 2014, a total of four special-status animal species are assumed to have a moderate potential to occur in the project vicinity. In addition, one special-status animal has a low potential to occur in the project area, but could be affected by noise associated with construction of the project.

Special-status animal species with moderate potential to occur within the project area and potential to be affected by construction activities are discussed in more detail below.

4.5.1 Species with Moderate Potential to be Present

<u>Amphibians and Reptiles</u>

California Red-legged Frog

California red-legged frog (*Rana draytonii*, CRLF) is listed as federally threatened and is designated by the state as a CSSC. CRLF occurs in different habitats depending on life stage, season, and weather conditions. CRLF typically use a variety of aquatic habitats (e.g., ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, perennial creeks, artificial ponds, marshes, dune ponds, and lagoons), as well as riparian and upland habitats. The common factor among habitats where CRLF occur is the association with a permanent water source, ideally free of non-native predators (USFWS 2002). Although CRLF is largely absent from urban and suburban settings (Bulger et al. 2002), potential habitat is present within close proximity to the project area within Matadero Creek near Hillview Avenue. Potential habitat is also present northwest of the project area within Matadero Creek near Deer Creek Road. Several occurrences of CRLF have been recorded in the CNDDB within 5 miles of the project area. Three adults and five larvae were observed in an artificial pond 0.5-mile south southwest of Bear Gulch Reservoir in 1998. Multiple adults, tadpoles, and juveniles were observed in Matadero Creek, Deer Creek, and San Francisquito Creek between 1997 and 2001. One juvenile was observed in an unnamed creek 0.4-mile southeast of Bear Gulch Reservoir in 2003 (CDFW 2014). Based on the presence of moderately suitable habitat and on recent and nearby CNDDB occurrences, CRLF are considered to have a moderate potential to occur within the proposed project area.

<u>Birds</u>

Burrowing Owl

Burrowing owl (*Athene cunicularia*, BUOW) is designated as a CSSC by the CDFW. The BUOW is a ground dwelling owl, typically found nesting in arid prairies, fields, and open areas where vegetation is sparse and low to the ground. It is heavily dependent upon the presence of mammal burrows (e.g., ground squirrel) in its habitat to provide shelter from predators or inclement weather, as well as to provide a nesting location. Foraging habitat is often present in grassland areas. The BUOW has disappeared from a significant portion of its range in the last 15 years. Nearly 60% of the breeding groups of BUOW known to have existed in California during the 1980s had disappeared by the early 1990s (California Burrowing Owl Consortium, 1993). The conversion of grassland habitat has been a significant factor in the reduction of the local population. Because burrowing owls depend on other animals to dig their burrows, eradication of ground squirrels has also contributed to their decreased numbers (Haug et al. 1993). At present, approximately 50 pairs of BUOW remain in the entire county of Santa Clara (Trulio 2014). There are multiple occurrences of BUOW nesting and overwintering within 5 miles of the proposed project area, including three occurrences of overwintering owls at nearby Byxbee Park Hills as recently as March 2014 (TRA Environmental Sciences, Inc. 2014). There has been no breeding documented at Byxbee Hills Park since the early 1900s, but BUOW are known to breed within 2.5 miles at Shoreline Park in Mountain View. Pastureland habitat in the southern portion of the project area between Hillview Avenue and Deer Creek Road provides marginally suitable foraging and breeding habitat. Suitable foraging and breeding habitat is also present within the disturbed marsh habitat near RWQCP and additional foraging habitat is present at Byxbee Hills Park near the RWQCP. Based on the presence of moderately suitable habitat and on recent and nearby CNDDB occurrences, BUOW are considered to have a moderate potential to occur within the proposed project area.

Northern Harrier

Northern harrier (*Circus cyaneus,* NOHA) is designated as a CSSC by the CDFW. It nests and forages in fresh and saltwater marshes, and is seen fairly often foraging in upland grasslands. This medium-sized raptor often flies close to the ground while hunting for small mammals and birds. The male and female of this species are highly sexually dimorphic. The female is larger than the male and has dominantly brown colored plumage while the male is dominated with gray plumage. Both the male and female have white rumps that are obvious during flight (Sibley 2000). There are three CNDDB occurrences of nesting NOHA within 5 miles of the proposed project area. All three of these occurrences are in salt marsh habitat. The project area does not support any suitable nesting habitat, but NOHA have a moderate potential to forage within the pastureland habitat at the southern portion of the proposed project area. Marshland areas north and east of the project area support suitable nesting and foraging habitat for NOHA; therefore, they could be expected to fly through the project area. NOHA is considered to have a moderate potential to occur within the proposed project area.

Salt Marsh Common Yellowthroat

Salt marsh common yellowthroat (*Geothlypis trichas sinuosa*, SMCY) is designated as a CSSC by the CDFW. This species inhabits thick, tangled vegetation, particularly in wet areas. In Santa Clara County, SMCY is a regular breeder and is fairly common in the fall, winter, and spring, and common in the summer (Bousman, W. G. 2007). Nesting sites for SMCY may be over water, in emergent aquatic vegetation, dense shrubs, or other dense growth. Nests are typically on or within 10 centimeters of the ground. The nesting season generally extends from early April to mid-July, with peak activity in May and June.

The project area does not support potential nesting habitat for SMCY. However, this species may occasionally forage within the project area, particularly east of East Bayshore Road in the vicinity of the preferred alignment and at the crossings of Adobe Creek at Highway 101 and

East Meadow Drive. Potential nesting habitat is present in the marsh and riparian habitats within the Baylands Marsh Nature Preserve. There are several occurrences of SMCY recorded in the CNDDB within a 5 miles of the proposed project area, including a record from 1985 of five breeding pairs at the end of Mayfield Slough, a record at the junction with Matadero Creek, and a record from 1985 of two breeding pairs at Adobe Creek just east of Hwy 101 (CDFW 2014). Therefore, SMCY may fly through the project area to reach suitable foraging and nesting habitat. As a result, SMCY is considered to have a moderate potential to occur within the proposed project area.

Other Migratory Birds and Raptors

In addition to the bird species discussed above, habitats in the vicinity of the project, particularly the northern coastal salt marsh, coastal freshwater marsh, and willow riparian habitats east of the project area, support potential nesting habitat for other migratory birds and raptors, such as American kestrel (*Falco sparverius*), red-winged blackbird (*Agelaius phoeniceus*), western meadowlark (*Sturnella neglecta*), and yellow warbler (*Dendroica petechia brewsteri*). In addition, the ornamental vegetation interspersed throughout the urban area, such as landscape trees, support potential nesting habitat for common migratory species, such as house finch (*Carpodacus mexicanus*), Anna's hummingbird (*Calypte anna*), Mourning dove (*Zenaida macroura*), and bushtit (*Psaltriparus minimus*). The roadway overpasses and recreational bridges crossing the creeks within the project area also support potential nesting habitat for those species that attach their nests to structures, such as cliff swallow (*Petrochelidon pyrrhonata*), barn swallow (*Hirundo rustica*), and black phoebe (*Sayornis nigricans*). Although only some of these species are listed by the CDFW and/or USFWS, all are protected under the MBTA. As discussed in Section 2.1.4, the MBTA prohibits taking, killing, possessing, transporting, and importing of migratory birds, and their eggs and nests, except when specifically authorized by the Department of Interior. The term "take" is defined as meaning, "to pursue, hunt, capture, collect, kill or attempt to pursue, hunt, shoot, capture, collect or kill, unless the context otherwise requires." Disturbances that cause nest abandonment and/or loss of reproductive effort or loss of habitat upon which these birds depend would be in violation of the MBTA, as well as other state and federal regulations for those species specifically protected by these agencies.

Bat species

The creek crossings, oak woodlands, and grassland habitats adjacent to the project area could provide foraging and marginal roosting habitat for the pallid bat (*Antrozous pallidus,* CSSC) and Townsend's big-eared bat (*Corynorhinus townsendii*, CSSC). CNDDB occurrences for the pallid bat and Townsend's big-eared bat have been documented within 5 miles of the project area (CDFW 2014). Additionally, the project area does provide some suitable foraging habitat in the trees and bridges at the Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street. Bridges frequently have structural features very similar to natural roosts, and the large mass, particularly in concrete bridges, offers the kind of thermal buffering that bats require. They frequently serve to replace natural roosts in anthropogenically-altered landscapes (Erickson et al. 2003). Additionally, bats tend to forage near water sources, and so roadway bridges over water bodies are even more likely to serve as roosting sites. Therefore, these species, as well as several other non-sensitive bat species, have potential to use roadway bridges and landscape trees as day or night roosting locations.

4.5.2 Species with Low Potential to be Present (but could be disturbed by project activities)

California Clapper Rail

California clapper rail (*Rallus longirostris obsoletus*) is federally- and state-listed as endangered. The clapper rail is a year-round resident of the San Francisco Bay associated with salt and brackish marshes traversed by tidal sloughs. In the South and Central San Francisco Bay, clapper rails typically inhabit salt marshes dominated by pickleweed (*Salicornia pacifica*) and cordgrass (*Spartina foliosa*). Nesting begins in late March, peaking in late-April and May, and extends into early July.

Potential foraging and nesting habitat for clapper rails does not occur in much of the study area. However, the RWQCP is located within the Baylands Preserve, which contains northern coastal salt marsh habitat that supports potential habitat for clapper rails. There are several occurrences of clapper rail recorded in the CNDDB within a five-mile radius of the Project. The potential for construction-related activities to adversely affect clapper rails is considered low given the existing levels of human-related disturbances in the Project vicinity, but the USFWS and CDFW typically recommend surveys be conducted for projects within 500 feet of potential nesting habitat to avoid disturbance of clapper rails during the nesting season (Browning, 2006).

5 Environmental Impact Assessment

This section describes potential impacts to sensitive biological resources, including special-status plants and animals, and waters of the U.S. and the state, that may occur within the proposed project area. Each impact discussion is accompanied by avoidance and minimization measures (AMMs) that would be implemented during the proposed project to avoid and/or reduce the potential for and/or level of impacts to each resource. A complete list of AMMs that have been proposed has been included in Section 6.0 Conclusions and Recommendations. With the implementation of the AMMs, all impacts are anticipated to be reduced to less than significant pursuant to CEQA.

5.1 Significance Criteria

Potential impacts to biological resources were determined in accordance with Appendix G of the CEQA Guidelines. Impacts would be considered potentially significant if the proposed project will:

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 CDFW or USFWS

b) Have a substantial adverse effect on any sensitive natural community identified in local or regional plans, policies, or regulations, or by the CDFW or USFWS

c) Have a substantial adverse effect on federally protected wetlands, as defined by Section 404 of the CWA (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrologic 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 local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance

f) Conflict with the provisions of an adopted HCP, Natural Community Conservation Plant (NCCP), or other approved local, regional, or state HCP

Direct take of a federally or state-listed species will be considered a significant impact. Temporary and/or permanent habitat loss is not considered a significant impact to sensitive species (other than for listed or candidate species under the FESA and CESA) unless a significant percentage of total suitable habitat throughout the species' range is degraded or somehow made unsuitable, or areas supporting a large proportion of the species' population are substantially and adversely impacted.

Potential impacts to nesting bird species will be considered significant due to their protection under the MBTA, and such impacts will need to be avoided.

5.1.1 Biological Resources IV. a – Sensitive Species – *Less than Significant Impact*

Special-status Plants

No special-status plant species or suitable habitat for special-status plant species were observed within the project area during the biological surveys in May 2011 and November 2014. In addition, no sensitive plant species with a moderate or high potential to occur within the project area were identified during the literature review. Some special-status plant species were identified during the literature review as having a low potential to occur in the proposed project area. However, because all construction activities will occur within previously disturbed areas (e.g., paved roads or along existing maintained right of way), special-status plant species with a low potential to occur are not anticipated to be impacted. As a result, no impacts to special-status plants are anticipated during construction of the proposed project.

Special-status Animals

CRLF has potential to occur within Matadero Creek and in the pastureland habitat between Deer Creek Road and Hillview Avenue. Construction of the proposed project could result in temporary indirect impacts to CRLF, such as displacing CRLF due to increased noise levels or decreasing habitat quality by temporarily decreasing water quality. There is also some potential for direct impacts to CRLF in these areas if a CRLF is present in the proposed project area. However, implementation of AMMs, as described in Section 6.0 Conclusions and Recommendations, such as conducting environmental awareness training, developing and implementing a SWPPP, implementing BMPs, conducting activities in the dry season when feasible, and retaining a qualified biologist to monitor construction in these areas, will reduce impacts to CRLF to less-than-significant.

NOHA and SMCY have the potential to forage in the proposed project area and to nest adjacent to the proposed project area. Impacts to nesting NOHA and SMCY are not anticipated as a result of the proposed project because no suitable habitat is present within the project area. However, foraging NOHA and SMCY could be temporarily impacted during construction activities due to increased noise levels and human activity in the work areas. Since there is an abundance of additional foraging habitat present in the immediate vicinity of the proposed project area, impacts to foraging NOHA and SMCY are anticipated to be less-than-significant.

Breeding, wintering, or foraging BUOW could occur near the RWQCP and within the pastureland habitat at the southern section of the project area between Deer Creek Road and Hillview Avenue. Impacts to burrowing owl may include the removal of potential breeding or wintering habitat (e.g., destruction of ground squirrel burrows) and the disruption of breeding, wintering, or foraging behavior due to a temporary increase in noise from construction equipment and vehicles. However, the majority of the proposed project is located in an industrial area near numerous major roadways (including Embarcadero Road, Highway 101, Page Mill Road) and near existing facilities (including the SAP campus, RWQCP, and the landfill); therefore, impacts from construction noise are not anticipated to increase substantially from existing levels. In addition, AMMs will be implemented, as described Section 6.0 Conclusions and Recommendations, to further reduce impacts to BUOW to less-than-significant. These AMMs include, but are not limited to, avoiding wildlife to the extent practicable and conducting pre-construction BUOW surveys prior to construction in suitable habitat.

Although CCR was determined to have low potential to occur in the proposed project area because it is more than 500 feet away from any known, documented nesting sites, impact to CCR could occur because of suitable habitat along Embarcadero Way. However, this habitat is more than 470 feet from the proposed construction activities and it is unlikely that impacts to CCR would occur due to Project implementation. Impacts to CCR include the disruption of breeding or foraging behavior due to a temporary increase in noise from construction equipment and vehicles. Because of the reclusive nature of this species disturbance could be difficult to detect; therefore, it is assumed that impacts to CCR could occur if construction activities take place within 500 feet of suitable marshland habitat for CCR. However, given that an existing road (i.e., Embarcadero Road), which is used by landfill vehicles, is present between the marshland habitat where CCR may occur and the RWQCP where construction activities will occur, impacts from construction are not anticipated to increase substantially from existing levels along Embarcadero Road. AMMs will be implemented, as described Section 6.0 Conclusions and Recommendations, to further reduce impacts to CCR to less-than-significant. These AMMs include, but are not limited to, avoiding the breeding season to the extent feasible and conducting protocol-level CCR surveys prior to construction within 500 feet of marshland habitat.

The use of recycled water would not affect any special-status wildlife species. The City currently provides recycled water under its waste discharge requirements for the City of Palo Alto RWQCP (Order No. 93-160) and would amend this permit to provide recycled water to new customers proposed as part of this project. Prohibitions of the permit include the following:

- No reclaimed water used for irrigation shall be applied during periods of rainfall or when soils are saturated such that runoff occurs;
- No reclaimed water use for irrigation shall be allowed to escape to areas outside the designated use areas by surface flow or by airborne spray.
- No reclaimed water shall be discharged from the treatment facilities, irrigation holding tanks, storage ponds, man-made marsh, or other containment, other than for irrigation or industrial reuse in accordance with this Order or for discharge to a municipal sewage collection system.

The prohibitions above would ensure that recycled water would not runoff irrigation sites into any sensitive habitat and affect the habitat or special-status animal species. Thus, no impacts would occur.

Nesting Birds

Some common avian species may nest within or in the vicinity of the proposed project area. Impacts to nesting bird species may include the removal of potential nesting habitat (e.g., from trimming and/or removal ornamental vegetation, trees) and the disruption of nesting behavior due to a temporary increase in noise from construction equipment and vehicles. However, the majority of the proposed project alignment is located in highly developed areas near numerous major roadways (including Embarcadero Road, Highway 101, and Page Mill Road) and thus potential nesting birds are already highly adapted to existing noise impact. Therefore, impacts from construction noise are not anticipated to increase substantially from existing levels. Because impacts to nesting birds could potential occur, AMMs will be implemented, as described Section 6.0 Conclusions and Recommendations, to further reduce impacts to nesting birds to less-than-significant. These AMMs include, but are not limited to, avoiding wildlife to the extent practicable and conducting pre-construction nesting bird surveys during the breeding season.

Bats

Bat species may forage or roost within the proposed project area, especially in the vicinity of the Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street. Noise, vibration, and increased light can lead to the temporary disturbance of roosting or foraging bats. In addition, if bats are roosting under the bridges at these crossings, they could be temporarily displaced from roosting at these locations during activities associated with the installation of the pipeline on or in the vicinity of the bridge. However, AMMs will be implemented, as described in Section 6.0 Conclusions and Recommendations, to reduce impacts to roosting bat species to less-than-significant. These AMMs include, but are not limited to, working during daylight hours to the extent feasible and conducting pre-construction bat surveys prior to construction or during the bat breeding season.

5.1.2 Biological Resources IV. b – Sensitive Natural Vegetation Communities – *Less-than-Significant Impact*

Sensitive vegetation communities include riparian habitat or other sensitive natural communities identified in local or regional plans, policies, or regulations, or as designated by the USFWS and CDFW. No sensitive natural communities are present within the proposed project area. However, because sensitive natural communities are present in the vicinity of the project area, the proposed project could have indirect impacts (e.g., inadvertent damage by construction equipment or decreased water/habitat quality due to runoff) on these sensitive natural communities. However, with the implementation of AMMs in Section 6.0 Conclusions and Recommendations including , but not limited to, developing and implementing a Stormwater Pollution Prevention Plan (SWPPP), implementing Best Management Practices (BMPs), and preparing a hazardous spill plan, these impacts would be reduced to less-than-significant.

5.1.3 Biological Resources IV. c – Jurisdictional Waters – *Less-than-Significant Impact*

Three jurisdictional waters (i.e., Adobe Creek, Barron Creek, and Matadero Creek) are present within the proposed project area. No direct impacts to these waters will occur because all pipelines would be constructed either by hanging from a bridge or using trenchless construction beneath the channel. Trenchless construction can be accomplished without surface disturbance of the channels; however, construction must be performed carefully to avoid the highly unlikely risk of an uncontrolled release of drilling fluids from construction of the pipeline and the stream (i.e., frac-out). Implementation of AMM-4 in Section 6.0 Conclusions and Recommendations will be implemented to protect against frac-out. The proposed project could have indirect impacts (e.g., inadvertent damage by construction equipment or decreased water/habitat quality due to runoff) on these jurisdictional waters. However, with the implementation of AMMs in Section 6.0 Conclusions and Recommendations including, but not limited to, developing and implementing a Stormwater Pollution Prevention Plan (SWPPP), implementing Best Management Practices (BMPs), and preparing a hazardous spill plan, these impacts will be reduced to less-than-significant.

5.1.4 Biological Resources IV. d – Interfere with Native Wildlife Movement – *No Impact*

Although wildlife may use the project area as a travel route as they move between the habitats in the project vicinity and those adjacent to the project area or as a stepping stone during larger scale movements, the project is primarily urban and is not located within an established movement corridor. Additionally, the project is not a known wildlife nursery site. All proposed creek crossings will use trenchless techniques that will not impact resident or migratory fish. For these reasons, construction and operation of the proposed project will not impact wildlife corridors or nursery sites.

5.1.5 Biological Resources IV.e – Conflict with Local Policies – *Less than Significant*

The Palo Alto Comprehensive Plan (Palo Alto 2007) and the Palo Alto Municipal Code protect biological resources within the City's limits. The City's Comprehensive plan defines policies for protecting creeks and riparian areas, wetlands, urban forest, and wildlife.

Regulated trees (protected trees, street trees growing within the street right-of-way, and designated trees) could be removed during the construction activities and as such could conflict with the City's Municipal Code and the Tree Technical Manual. Any necessary tree removal would occur on City owned land, public utility easement, or on leased or private property (e.g., Mayfield Soccer Fields, parking lot adjacent to Fabian Road). Protected trees would remain. Designated trees would be protected or replaced according to the Tree Canopy Replacement Formula, Tree Technical Manual, Section 3.30, and street trees would be replaced with species determined by Public Works Operations. Tree removal of non-protected trees could occur on City owned land, public utility easement (PUE), private property (e.g., Mayfield Soccer Fields), or leased land. The City must comply with the Tree Technical Manual regarding the removal and replacement of trees. Compliance with the Manual's practices would ensure that potential conflicts would be reduced to less than significant.

Installation of the pump station at the RWQCP would not conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance. The pump station would comply with the requirements of both the Baylands Master Plan and Santa Clara County's Airport Master Plan for the Palo Alto Airport. The trees on the site proposed for the pump station at the RWQCP are not protected by City of Palo Alto Municipal Code Chapter 8.10.

With the implementation of AMMS in Section 6.0 Conclusions and Recommendations that protect special-status wildlife and vegetation, natural vegetation communities, and aquatic resources, the proposed project will not conflict with any local environmental policies or ordinance promulgated to protect biological resources.

5.1.6 Biological Resources IV. f– Conflict with Conservation Plan – *Less than Significant*

The proposed project is within the area covered by the Stanford University HCP. The proposed project is not covered by the HCP. However, the AMMs in Section 6.0 Conclusions and Recommendations are compatible with the AMMs in the HCP. As a result, the proposed project will not conflict with the HCP. No Habitat Conservation Plans, Natural Community Conservation Plans, or other local or regional plans have been adopted within the City, which encompasses the Project area.

6 Conclusions and Recommendations

The following section provides recommended Avoidance and Minimization Measures (AMMs) that should be incorporated prior to, during, and post-construction of the project in order to minimize impacts to sensitive habitats (including jurisdictional wetlands and waters) and special-status species (including federal and state-listed species).

6.1 Sensitive Habitats and Jurisdictional Features

The proposed project has been designed to avoid impacts to sensitive habitats, including jurisdictional wetlands and waters. However, indirect impacts to jurisdictional waters could occur as a result of the proposed project. The following general AMMs will be implemented during the construction and operation of the proposed project to minimize indirect impacts to sensitive habitats and jurisdictional features:

1. All construction equipment will use identified staging areas and access roads located in upland areas. When accessing work sites, travel and parking of vehicles and equipment will be limited to pavement, existing roads, and previously disturbed areas (except where overland travel is required). Construction workers will not be allowed to enter sensitive areas that have been fenced or staked.

2. Ground disturbance and vegetation removal will not exceed the minimum amount necessary to complete work at the site.

3. The potential for adverse effects to water quality will be avoided by implementing temporary BMPs. BMPs will be used to minimize any wind- or water-related erosion. Protective measures will include:

   a) No discharge of pollutants from vehicle and equipment cleaning will be allowed into storm drains, wetlands, or water courses.

   b) No vehicles may be refueled within 100 feet of wetlands, streams, or other waterways. Vehicles operating adjacent to wetlands and waterways must be inspected and maintained daily to prevent leaks.

   c) Waste facilities will be maintained. Waste facilities include concrete wash-out facilities, porta-potties, and hydraulic fluid containers. Waste will be removed to a proper disposal site. [bio report covered]

4. Prior to constructing underground crossings of creeks or channels, a Frac-out Contingency Plan will be developed. At a minimum, the plan will prescribe the measures to ensure protection of water quality and related biological resources (e.g., aquatic resources, and special-status plants and wildlife) including:

   a) Procedures to minimize the potential for frac-out associated with HDD activity;

   b) Procedures for timely detection of frac-outs;

c) Procedures for timely response and remediation in the event a frac-out; and

d) Monitoring of drilling and frac-out response activities by a qualified biologist.

5. A SWPPP that complies with the statewide General Permit administered by the State Water Board for the National Pollutant Discharge Elimination System will be developed and implemented to protect the water quality of aquatic resources that lie in or adjacent to the proposed project area. Appropriate erosion and sediment control and non-sediment pollution control (i.e., sources of pollution generated by construction equipment and material) BMPs will be prescribed in the SWPPP, and erosion and sediment control material included in the SWPPP will be certified as weed-free.

6. A hazardous spill plan will be developed prior to construction. The plan will describe what actions will be taken in the event of a spill. The plan will also incorporate preventative measures to be implemented, such as vehicle and equipment staging, cleaning, maintenance, and refueling; and contaminant (including fuel) management and storage. In the event of a contaminant spill, work at the site will immediately cease until the contractor has contained, and mitigated the spill. The contractor will immediately prevent further contamination and notify appropriate authorities, and mitigate damage as appropriate. Adequate spill containment materials, such as oil diapers and hydrocarbon cleanup kits, will be available on site at all times. Containers for storage, transportation, and disposal of contaminated absorbent materials will be provided on the project area.

7. After construction is completed, a final cleanup will include removal of all stakes, temporary fencing, flagging, and other refuse generated by construction.

6.2 Special Status Species

6.2.1 Wildlife

Based on the biological surveys and habitat suitability analysis special-status wildlife species, including nesting birds, bats, CRLF, BUOW, and CCR were assumed to have a potential for occurrence in the project area vicinity.

Construction activities and operation of the proposed project are not expected to result in adverse effects to special-status wildlife; however, the following measures are recommended to avoid harming special-status wildlife species, bats, and nesting raptors and songbirds during construction:

1. **Employee Education Program** (required for CRLF, BUOW, and CCR if preconstruction surveys determine they are present)**.** An employee education program will be conducted by a qualified biologist, consisting of a brief presentation to explain special-status species concerns to contractors, their employees, and any other personnel involved in the project. The program will include the following: a description of relevant special-status species and their habitat needs as they pertain to the project; a report of the occurrence of these species in the project vicinity, as applicable; an explanation of the status of these species and their protection under the MBTA, California Fish and Game Code, and other statutes; and, a list of measures being taken to reduce potential impacts

to natural resources during project construction and implementation. A fact sheet conveying this information will be prepared for distribution to the above-mentioned people and anyone else who may enter the project area. Upon completion of training, employees will sign a form stating that they attended the training and understand all of the conservation and protection measures. Construction crews will be informed during the education program meeting that, to the extent possible, travel within the marked project area will be restricted to established roadbeds.

2. **Monitoring during Construction** (required for CRLF). A qualified biologist will be retained to monitor construction activities associated with the creek crossing (Matadero Creek near Deer Creek Road). The biologist will have expertise with CRLF biology and ecology. The biologist will have the authority to halt work if a special-status species is observed.

3. **Protection of Bats** (required for bats)**.** To the extent possible, nighttime (i.e. after sunset) construction will be minimized.

4. **Protection of CRLF** (required for CRLF)**.** To the extent possible, Construction activities associated with the creek crossing (Matadero Creek near Deer Creek Road) will be limited to the dry season (generally April 15 to October 15) to the extent feasible.

5. **Buffer for California Clapper Rail or Survey** (required for CCR)**:** Construction activities within 500 feet of the marshland habitat surrounding the RWQCP will be conducted outside the breeding season for CCR (i.e., September 1 through January 31). If this is not feasible, a qualified biologist will conduct protocol-level surveys for CCR in accordance with the California Clapper Rail Draft Survey Protocol (USFWS 2000). A qualified biologist is an individual who has experience conducting protocol-level surveys for CCR. Prior to commencement of the surveys, the biologist will prepare a brief letter report describing the survey design and submit it to the USFWS and the CDFW for review and approval. Upon the completion of the surveys, results will be submitted to the USFWS and CDFW for a final decision on the possibility of doing work during the breeding season for CCR.

6. **General Measures to Reduce Impacts to Wildlife Species** (required for CRLF, BUOW, and CCR). All excavations left open overnight will either be covered to prevent wildlife from becoming entrapped or will include escape ramps. In addition, excavations must be inspected for wildlife at the start of each workday and prior to back filling. The USFWS and/or CDFW will be contacted prior to removing or relocating any special-status wildlife within the excavation.

7. **General Measures to Reduce Impacts to Wildlife Species** (required for CRLF, BUOW, and CCR).Food items may attract wildlife into construction areas, which would expose them to construction-related hazards. The construction areas will be maintained in a clean condition. All trash (e.g., food scraps, cans, bottles, containers, wrappers, cigarette butts, and other discarded items) will be placed in closed containers and properly disposed of.

8. **General Measures to Reduce Impacts to Wildlife Species** (required for CRLF, BUOW, and CCR).If an animal is found at a work site and is believed to be a protected species, work must be halted until the animal leaves of its own accord or the USFWS and/or CDFW is consulted to relocate the species. Care shall be taken not to harm the species. No wildlife or plant species will be handled and/or removed from the site by anyone except approved biologists.

9. **Measure to Protect Nesting Birds (required for nesting birds):** If equipment staging, site preparation, grading, excavation, or other project-related construction activities are scheduled to occur during the avian nesting season (generally February 1 to September 1), a focused survey for active nests will be conducted by a qualified biologists within 15 days prior to the beginning of project-related activities. Surveys will be conducted in all suitable habitat located at project work sites, and in staging or storage areas. Surveys will be conducted at the appropriate times of day (e.g., dawn or dusk), and during the appropriate nesting times and will concentrate on areas of suitable habitat. If a lapse in project-related activities of 15 days or longer occurs, another focused survey will be conducted. If no active nests are found, then no further mitigation is required. If an active nest is found within the surveyed areas, an appropriate exclusion buffer will be established by a qualified biologist and the exclusion buffer will be maintained until the young have fledged or will no longer be impacted by the project. A qualified biologist will be present to monitor construction activities in the vicinity of the nest and ensure the nesting species is not disturbed. If a species appears disturbed by construction activities (as determined by a qualified biologist) work will be halted and the USFWS and/or CDFW will be consulted. Project activities will not resume without approval from the USFWS and/or CDFW.

10. **Burrowing Owl Pre-Construction Surveys** (required for BUOW)**:** Pre-construction BUOW surveys will be conducted in suitable habitat for BUOW (i.e., in pastureland habitat between Deer Creek Road and Hillview Avenue and in the vicinity of the RWQCP) in accordance with the recommendations and guidelines provided in the Staff Report on Burrowing Owl Mitigation (Department of Fish and Game, March 2012). If no BUOW or BUOW sign is observed no further action will be required. If BUOW or BUOW sign is observed then no disturbance will occur within 160 feet of occupied burrows during the non-breeding season (September 1 through January 31) or within 250 feet during the breeding season (February 1 through August 31). A qualified biologist will be present in these locations to monitor construction and ensure the BUOW is not disturbed.

11. **Bats Preconstruction Surveys** (Required for bats)**:** Preconstruction day and night-roost surveys will be conducted to avoid impacts to bats. If present, construction activities near Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street will be scheduled to occur during daylight hours to avoid impacts to night roosting bat species to the extent feasible. The survey will be conducted by a qualified bat biologist following the protocol in the Bats and Bridges Technical Bulletin (Erickson et al. 2003) to determine if bats are using the bridges as a roost site. If a roost is observed, the CDFW and/or USFWS will

be consulted and additional mitigation measures will be implemented. Example measures include no clearing or grubbing adjacent to the roost, no work within 100 feet of the roost, no lighting near the roost where it could shine on the roost structure.

12. **Bats Breeding Season Surveys** (required for Bats)**:**Construction activities near Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street will be scheduled to avoid the bat breeding season (April through August) to the extent feasible. If work in these locations is required in the breeding season, a survey for bats will be conducted. The survey will be conducted by a qualified bat biologist following the protocol in the Bats and Bridges Technical Bulletin (Erickson et al. 2003) to determine if bats are using the bridges as a roost site. If a roost is observed, the CDFW and/or USFWS will be consulted and additional mitigation measures will be implemented. Example measures include excluding bats from directly affected work areas or replacing the roost location.

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FIGURES

Figure 1 - Project area Location Map

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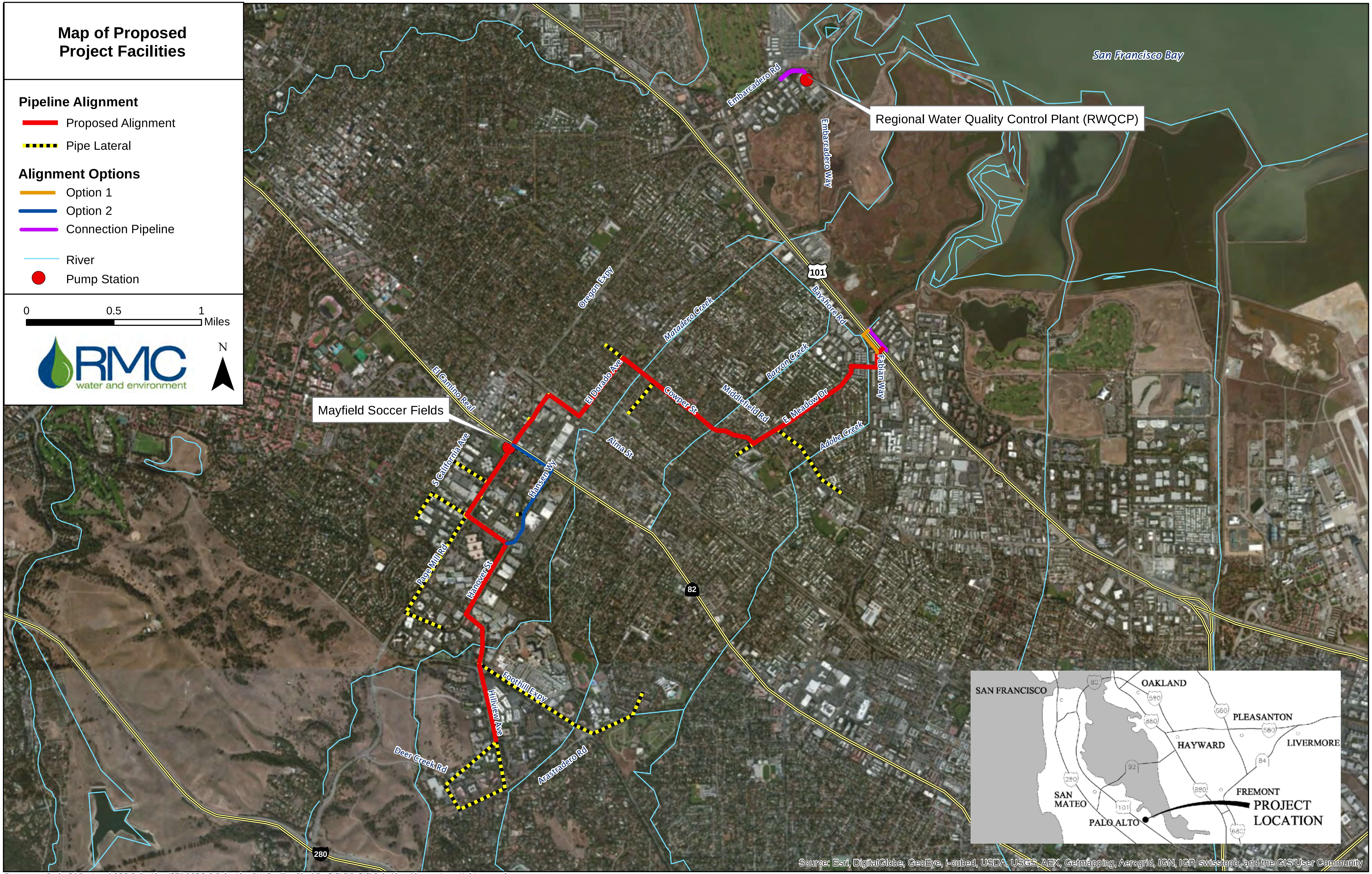

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APPENDICES

Appendix A - Special-Status Plant and Animal Species Evaluated for Potential to Occur within the Project area.

Table 1. Special-Status Plant Species Evaluated for Potential to Occur on the Project area.

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Alkali milk-vetch (*Astragalus tener* var. *tener*)	1B.2	Alkali milk-vetch is found in alkali playa, valley and foothill grassland and vernal pool habitat. It occurs at elevations below 200 feet.	March – June	One CNDDB occurrence for alkali milk-vetch has been documented within the 5 miles of the proposed project area; however, this occurrence is assumed to be extirpated. No suitable habitat for this species is present within the project area. **Not Expected**
Anderson's manzanita (*Arctostaphylos andersonii*)	1B.2	Anderson's manzanita is found in the openings and edges of broad-leafed upland forest, chaparral, and north coast coniferous forest. It occurs at elevations from approximately 200 to 2,500 feet.	November – May	There are no CNDDB occurrences for Anderson's manzanita within 5 miles of the proposed project area. The project area is dominated by disturbed and developed lands and no suitable habitat for this species is present within the project area. **Not Expected**
Arcuate bush-mallow (*Malacothamnus arcuatus*)	1B.2	Arcuate bush-mallow is found growing in chaparral and cismontane woodland habitats. It occurs at elevations between 50 and 1,160 feet.	April - September	There are three CNDDB occurrences for arcuate bush-mallow documented within 5 miles of the proposed project area. The most recent record was documented in 2010 at Jasper Ridge Biological Preserve. The two other occurrences were documented in 1926 and 1931. The project area is dominated by disturbed and developed lands and no suitable habitat for this species is present within the project area. **Not Expected**
Ben Lomond buckwheat (*Eriogonum nudum* var. *decurrens*)	1B.1	Ben Lomond buckwheat occurs in sandy soils in chaparral, cismontane woodland, and lower montane forest habitats. It is found in maritime ponderosa pine sandhill microhabitats in Santa Cruz County. It occurs at elevations from approximately 160 to 2,600 feet.	June – October	There are no CNDDB occurrences of Ben Lomond buckwheat documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Bent-flowered fiddleneck (*Amsinckia lunaris*)	1B.2	Bent-flowered fiddleneck occurs in coastal bluff scrub, cismontane woodland, and valley and foothill grassland habitats. It occurs at elevations from near sea level to 1,600 feet.	March – June	No CNDDB occurrences for bent-flowered fiddleneck have been documented within 5 miles of the proposed project area. Although pastureland habitat is present in the vicinity of the pipeline lateral at the southern end of the project area between Deer Creek Road and Hillview Avenue, this area is frequently disturbed and vegetation is limited to non-native grasses and herbs. Therefore, no suitable habitat for this species is present within the project area. **Not Expected**
Brittlescale (*Atriplex depressa*)	1B.2	Brittlescale occurs in alkaline scalds and alkaline clay soils in chenopod scrub, meadows and seeps, playa, and valley and foothill grassland habitats. In addition, it is infrequently associated with riparian marshes or vernal pools. It occurs at elevations below 1,050 feet.	April – October	No CNDDB occurrences for brittlescale have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
California seablite (*Suaeda californica*)	FE 1B.1	California seablite is found growing in coastal salt marshes and swamps, playas, and vernal pools. It occurs at elevations between 0 and 50 feet.	July – October	A single CNDDB occurrence for California seablite has been documented within 5 miles of the proposed project area. This occurrence was documented at the salt flats of Palo Alto Yacht Harbor in 1971. No suitable habitat is present within the project area. **Not Expected**
Chaparral harebell (*Campanula exigua*)	1B.2	Chaparral harebell is found in chaparral habitat, in rocky conditions, usually in serpentinite soils. It occurs at elevations from approximately 900 to 4,100 feet.	May – June	No CNDDB occurrences for chaparral harebell have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. In addition, the project area is outside this species elevation range. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Choris' popcorn-flower (*Plagiobothrys chorisianus var. chorisianus*)	1B.2	Choris' popcorn-flower grows in mesic chaparral, coastal prairie, and coastal scrub habitats. It occurs at elevations between 50 and 520 feet.	March – June	There is a single extant CNDDB occurrence for Choris' popcorn-flower documented within 5 miles of the proposed project area. This occurrence was documented in 1898. No suitable habitat for this species is present within the project area. **Not Expected**
Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*)	1B.2	Condon's tarplant is found in alkaline valley and foothill grassland habitats. It occurs at elevations below 750 feet.	May – November	Two extant CNDDB occurrences for Congdon's tarplant have been documented within 5 miles of the propose project area. The only grassland habitat present at the project area occurs at the southern end of the alignment between Deer Creek Road and Hillview Avenue and consists of pastureland habitat made up of non-native grasses. Additionally, no alkaline soils or substrates are likely to be present at this location. **Low Potential**
Coastal marsh milk-vetch (*Astragalus pyncostachyus var. pynchostachyus*)	1B.2	Coastal marsh milk-vetch is found in mesic coastal dune, and in coastal scrub, and coastal marsh and swamp habitats. It occurs at elevations from sea level to approximately 100 feet.	April – October	No CNDDB occurrences for coastal marsh milk-vetch have been documented within 5 miles of the proposed project area. Although the marshlands north and east of the project area contain suitable habitat for this species, no suitable habitat is present within the project area. **Not Expected**
Contra Costa goldfields (*Lasthenia conjugens*)	1B.1	Contra Costa goldfields occurs in cismontane woodlands, alkaline playas, valley and foothill grassland, and mesic vernal pool habitats. It occurs at elevations between zero and 470 meters.	March – June	No CNDDB occurrences for Contra Costa goldfields have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Crystal Springs lessingia (*Lessingia arachnoidea*)	1B.2	Crystal Springs lessingia grows in cismontane woodland, coastal scrub, and valley and foothill grassland habitat. It often occurs in serpentinite soils and along roadsides. It occurs at elevations between 20 and 650 feet.	July – October	Crystal Springs lessingia is only known from locations near Crystal Springs Reservoir. No CNDDB occurrences for this species have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Davidson's bush-mallow (*Malacothamnus davidsonii*)	1B.2	Davidson's bush-mallow grows in chaparral, cismontane and riparian woodland, and coastal scrub habitats. It occurs at elevations between 600 and 2,800 feet.	June – January	One CNDDB occurrence for Davidson's bush mallow has been documented within 5 miles of the proposed project area. This was last observed in 1936 in the foothills near Stanford University. It typically occurs at elevations higher than the project area and no suitable habitat for this species is present within the project area. **Not Expected**
Dudley's lousewort (*Pedicularis dudleyi*)	CR 1B.2	Dudley's lousewort grows in maritime chaparral, cismontane woodland, north coast coniferous forest, and valley and foothill grassland habitats. It occurs at elevations between 200 and 3,000 feet.	April – June	No CNDDB occurrences for Dudley's lousewort have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Crystal Springs fountain thistle (*Cirsium fontinale* var. *fontinale*)	FE CE 1B.1	Crystal Springs fountain thistle is found in serpentinite seeps in openings in chaparral, cismontane woodland, and valley and foothill grassland habitats. It occurs at elevations from 150 to 570 feet.	May – October	No CNDDB occurrences for Crystal Springs fountain thistle have been documented within 5 miles of the proposed project area. This species is known from only five occurrences in the vicinity of Crystal Springs Reservoir. No suitable habitat for this species is present within the project area. **Not Expected**
Fragrant fritillary (*Fritillaria liliacea*)	1B.2	Fragrant fritillary is often found on serpentine soils in cismontane woodland, coastal scrub, valley and foothill grassland, and coastal prairie habitats. It occurs at elevations below 1,350 feet.	February - April	There is a single CNDDB occurrence for fragrant fritillary documented within 5 miles of the proposed project area. This occurrence is dated 1934 and was found near Lake Lagunitas on the Stanford University campus. No suitable habitat for this species is present within the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Franciscan onion (*Allium peninsulare* var. *franciscanum*)	1B.2	Franciscan onion is found in clay, volcanic or serpentinite soils in cismontane woodland and valley and foothill grassland habitats. It occurs at elevations from approximately 170 to 980 feet.	May – June	Two extant CNDDB occurrences for Franciscan onion have been documented within 5 miles of the proposed project area. One occurrence was observed in 1902 and one in 2003. The 2003 occurrence is located at Jasper Ridge Biological Preserve. Some marginal grassland habitat is present within southern portion of the project area in the pastureland habitat between Deer Creek Road and Hillview Avenue; however, this habitat is disturbed and is unlikely to support special-status plant species. No other suitable habitat for this species is present within the project area. **Low Potential**
Hall's bush-mallow (*Malacothamnus hallii*)	1B.2	Hall's bush mallow is found growing in chaparral and coastal scrub habitats. It occurs at elevations between 30 and 2,500 feet.	May – October	No CNDDB occurrences for Hall's bush-mallow have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Hairless popcorn-flower (*Plagiobothrys glaber*)	1A	Hairless popcorn-flower is found in alkaline meadows and seeps, and in coastal salt marshes and swamps. It occurs at elevations between 50 and 600 feet.	March – May	No CNDDB occurrences for hairless popcorn-flower have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Hillborough chocolate lily (*Fritillaria biflora* var. *ineziana*)	1B.1	Hillsborough chocolate lily is found in cismontane woodland and valley and foothill grassland habitats in serpentinite soils. It occurs at elevations below 500 feet.	March – April	Hillsborough chocolate lily is known only from the Hillsborough area. No CNDDB occurrences have been documented within 5 miles of the proposed project area. The pastureland habitat in the southern portion of the project area between Deer Creek Road and Hillsview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Low Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Hoover's button-celery (*Eryngium aristulatum* var. *hooveri*)	1B.1	Hoover's button-celery is a vernal pool obligate species. It occurs at elevations below 150 feet.	July – August	There are two CNDDB occurrences for Hoover's button celery documented within 5 miles of the proposed project area. However, these occurrences are dated 1907 and 1909. No suitable vernal pool habitat is present within the project area. **Not Expected**
King's Mountain manzanita (*Arctostaphylos regismontana*)	1B.2	King's Mountain manzanita occurs in granitic or sandstone soils in broad-leafed upland forest, chaparral, and north coast coniferous forest habitats. It occurs at elevations from approximately 1,000 to 2,400 feet.	January – April	No CNDDB occurrences for King's Mountain manzanita have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. In addition, the project area is outside this species elevation range. **Not Expected**
Legenere (*Legenere limosa*)	1B.1	Legenere is a vernal pool obligate species. It occurs at elevations below 2,900 feet.	April – June	One CNDDB occurrence for legenere has been documented within 5 miles of the proposed project area; however, this species was last observed in 1906. No suitable vernal pool habitat for this species is present within the project area. **Not Expected**
Loma Prieta hoita (*Hoita strobilina*)	1B.1	Loma Prieta hoita is found in chaparral, cismontane woodland, and riparian woodland habitats. It usually grows in serpentinite soils in mesic conditions. It occurs at elevations between 100 and 2,800 feet.	May – October	No CNDDB occurrences for Loma Prieta hoita have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Lost thistle (*Cirsium praeteriens*)	1A	Habitat for lost thistle is not known since this species is presumed extinct in California. It occurs at elevations below 320 feet.	June – July	Lost thistle is presumed extinct in California. One CNDDB occurrence of this species was documented within 5 miles of the proposed project area at the turn of the 20th century. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Marin western flax (*Hesperolinon congestum*)	FT CT 1B.1	Marin western flax occurs in serpentine soils in chaparral and valley and foothill grassland habitats. It occurs at elevations below 1,213 feet.	April – July	No CNDDB occurrences for Marin western flax have been documented within 5 miles of the proposed project area. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillsview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Low Potential**
Most beautiful jewel-flower (*Streptanthus albidus* ssp. *peramoenus*)	1B.2	Most beautiful jewel-flower grows in serpentinite soils in chaparral, cismontane woodland, and valley and foothill grassland habitat. It occurs at elevations between 360 and 3,280 feet.	March – October	No CNDDB occurrences for most beautiful jewel-flower have been documented within 5 miles of the proposed project area. The proposed project area is outside this species elevation range. **Low Potential**
Oregon polemonium (*Polemonium carneum*)	2B.2	Oregon polemonium grows in coastal prairie, coastal scrub, and lower montane coniferous forest. It occurs at elevations below 6,000 feet.	April – September	No CNDDB occurrences for Oregon polemonium have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Point Reyes bird's-beak (*Chloropyron maritimum* ssp. *Palustre*)	1B.2	Point Reyes bird's-beak is found in coastal salt marshes and swamps. It occurs at elevations below 30 feet. It was once common, but has been reduced by development, foot traffic, non-native plant species, alterations in hydrology, and cattle grazing and trampling.	June – October	This species is thought to be possibly extirpated in Santa Clara County. Two CNDDB occurrences have been documented for Point Reyes bird's beak in the salt marsh habitat east of proposed project area. These occurrences are dated 1914 and 1915. No suitable habitat for this species is present within the project area. **Not Expected**
Prostrate vernal pool navarretia (*Navarettia prostrata*)	1B.1	Prostrate vernal pool navarretia is found in mesic coastal scrub, meadows and seeps, alkaline valley and foothill grassland, and mesic vernal pool habitats. It occurs at elevations between 50 and 4,000 feet.	April – July	No CNDDB occurrences for prostrate vernal pool navarretia have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Saline clover (*Trifolium hydrophilum*)	1B.2	Saline clover occurs in marshes and swamps, mesic and alkaline valley and foothill grassland, and in vernal pool habitats. Many previously extant sites are thought likely to be extirpated. It occurs at elevations below 1,000 feet.	April – June	No CNDDB occurrences for saline clover have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
San Francisco Bay spineflower (*Chorizanthe cuspidata* var. *cuspidata*)	1B.2	San Francisco Bay spineflower grows in sandy soils in coastal bluff scrub, coastal dunes, coastal prairie, and coastal scrub habitats. It occurs at elevations from near sea level to 700 feet.	April – August	No CNDDB occurrences for San Francisco Bay spineflower have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
San Francisco campion (*Silene verecunda* ssp. *Verecunda*)	1B.2	San Francisco campion is found in sandy soils in coastal bluff scrub, chaparral, coastal prairie, coastal scrub, and valley and foothill grassland habitats. It occurs at elevations between 100 and 2,100 feet.	March – August	No CNDDB occurrences for San Francisco campion have been documented within 5 miles of the proposed project area. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillsview Avenue does not contain sandy soils and is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Not Expected**
San Francisco collinsia (*Collinsia multicolor*)	4.3	San Francisco collinsia is found in closed-cone coniferous forest and coastal scrub habitats, sometimes in serpentinite soils. It occurs at elevations from approximately 100 to 820 feet.	March – May	There is a single CNDDB occurrence for San Francisco collinsia documented within 5 miles of the proposed project area. This occurrence is dated 1903 and was observed in the vicinity of Stanford University. No suitable habitat for this species is present within the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
San Francisco owl's clover. (*Triphysaria floribunda*)	1B.2	San Francisco owl's clover usually occurs in serpentinite soils in coastal prairie, coastal scrub, and valley and foothill grassland habitat. It occurs at elevations from approximately 30 to 520 feet.	April – June	No CNDDB occurrences for San Francisco owl's clover have been documented within 5 miles of the proposed project area. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillsview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Not Expected**
San Joaquin spearscale (*Atriplex joaquiniana*).	1B.2	San Joaquin spearscale is found in alkaline chenopod scrub, meadows and seeps, playa, and valley and foothill grassland habitats. Many known occurrences of this species are extirpated. It occurs at elevations below 2,700 feet.	April – October	No CNDDB occurrences for San Joaquin spearscale have been documented within 5 miles of the proposed project area. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillsview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Not Expected**
San Mateo thorn-mint (*Acanthomintha* ssp.*duttonii*)	FE SE 1B.1	San Mateo thorn-mint grows in serpentinite soils in valley and foothill grassland and chaparral habitats. It occurs at elevations between 160 and 980 feet.	April – June	One CNDDB occurrence for San Mateo thorn-mint has been documented within 5 miles of the proposed project area; however, this occurrence is dated 1915 and is considered extirpated. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillsview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Not Expected**
San Mateo woolly sunflower (*Eriophyllum latilobum*)	FE CE 1B.1	San Mateo woolly sunflower is found growing in cismontane woodland habitats often on serpentinite soils and on roadcuts. It is known from two extant occurrences. It occurs at elevations between 150 and 500 feet.	May – June	No CNDDB occurrences for San Mateo woolly sunflower have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Short-leaved evax (*Hesperevax sparsiflora* var. *brevifolia*)	1B.2	Short-leaved evax is found in sandy soils in coastal bluff scrub, coastal dunes, and coastal prairies. It occurs at elevations between sea level and 700 feet.	March - June	No CNDDB occurrences for short-eared evax have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Slender-leaved pondweed (*Stuckenia filiformis*)	2B.2	Slender-leaved pondweed grows in shallow freshwater marshes and swamps. It occurs at elevations between 980 and 7,000 feet.	May – June	One CNDDB occurrence for slender-leaved pondweed has been documented within 5 miles of the proposed project area in 1899. No suitable marsh or swamp habitat for this species is present within the project area. In addition, the project area is outside this species elevation range. **Not Expected**
Robust spineflower (*Chorizanthe robusta* var. *robusta*)	FE 1B.1	Robust spineflower is found growing in sandy or gravelly soils in maritime chaparral, openings in cismontane woodland, coastal dunes, and coastal scrub habitats. Most populations of this species are extirpated. It occurs from approximately sea level to 1,000 feet.	April – September	No CNDDB occurrences for robust spineflower have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present within the project area. **Not Expected**
Round-leaved filaree (*California macrophylla*)	1B.1	Round-leaved filaree is found in clay soils in cismontane woodland and valley and foothill grassland habitats. It occurs at elevations from approximately 50 to 4,000 feet.	March – May	No CNDDB occurrences for round-leaved filaree have been documented within 5 miles of the proposed project area. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillsview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur
Western leatherwood (*Dirca occidentalis*)	1B.2	This species is found in mesic habitats including broad-leafed upland forest, closed-cone coniferous forest, chaparral, cismontane woodland, north coast coniferous forest, and riparian forest and woodland. It occurs at elevations from approximately 80 to 1,400 feet.	January – April	Multiple extant CNDDB occurrences of western leatherwood have been documented within 5 miles of the proposed project area. Although some habitat for this species occurs at the Matardero Creek crossings near Hillview Avenue, this habitat is highly disturbed and is not expected to support this species. **Low Potential**
White-flowered rein orchid (*Piperia candida*)	1B.2	White-flowered rein orchid grows in broad-leafed upland forest, lower coniferous forest, and north coast coniferous forest habitats, sometimes in serpentinite soils. It occurs at elevations between 100 and 4,300 feet.	March – September	A single CNDDB occurrence for white-flowered rein orchid has been documented within 5 miles of the proposed project area in 1992. No suitable habitat for this species is present in the project area. **Not Expected**
White-rayed pentachaeta (*Pentachaeta bellidiflora*)	FE CE 1B.1	White-rayed pentachaeta grows in cismontane woodland and valley and foothill grassland habitats and is often in serpentinite soils. It occurs at elevations between 100 to 2,000 feet.	March – May	No CNDDB occurrences for white-rayed pentachaeta have been documented within 5 miles of the proposed project area. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Not Expected**
Woodland woolythreads (*Monolopia gracilens*)	1B.2	Woodland woolythreads grows in serpentine soils in openings in broad-leafed upland forests, openings in chaparral, cismontane woodlands, north coast coniferous forests, and valley foothill grassland habitats. It occurs at elevations between 330 and 4,000 feet.	February – July	A single CNDDB occurrence for woodland woolythreads has been documented within 5 miles of the proposed project area at Jasper Ridge Biological Preserve. This occurrence was documented in 1971 and is presumed extant. The pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillview Avenue is likely too disturbed to support this species. No other suitable habitat for this species is present within the project area. **Low Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Flowering Phenology	Potential to Occur

STATUS KEY:
Federal
FE: Federally-listed Endangered
FT: Federally-listed Threatened

State
CE: California-listed Endangered
CT: California-listed Threatened
CR: California-listed Rare

California Native Plant Society (CNPS)**:**
Rank 1A – Presumed extinct in California;
Rank 1B – Rare, threatened, or endangered in California and elsewhere;
Rank 2A: Plants presumed extirpated in California, but more common elsewhere; Rank 2B: Rare, threatened, or endangered in California, but more common elsewhere;
Rank 3 – Plants for which more information is needed – A review list; and
Rank 4 – Plants of limited distribution – A watch list.
Additional threat ranks endangerment codes are assigned to each taxon or group as follows:
.1 – Seriously endangered in California (over 80% of occurrences threatened/high degree of immediacy of threat).
.2 – Fairly endangered in California (20-80% occurrences threatened).
.3 – Not very endangered in California (<20% of occurrences threatened or no current threats known).

Table 2. Special-Status Animal Species Evaluated for Potential to Occur on the Project area.

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Invertebrates			
Bay checkerspot butterfly (*Euphydryas editha bayensis*)	FT	Bay checkerspot butterfly is found in shallow, serpentine-derived soils in native grasslands supporting larval host plants, including dwarf plantain (*Plantago erecta*) or purple owl's clover (*Castilleja densiflora* or *Castilleja exserta*).	One CNDDB occurrence for Bay checkerspot butterfly has been documented within 5 miles of the proposed project area. A small area of potential serpentine outcrops is present within the pastureland habitat at the southern portion of the project area between Hillview Avenue and Deer Creek Road; however, this species has not been recorded near the project area since 1997. **Not Expected**
Myrtle's silverspot (*Speyeria zerene myrtleae*)	FE	Myrtle's silverspot is restricted to the foggy, coastal dunes or hill habitat of the Point Reyes Peninsula, although it previously occurred in coastal San Mateo County. The larval food plant for this species is thought to be *Viola adunca*.	Myrtle's checkerspot is thought to be extirpated from Santa Clara County. No CNDDB occurrences for this species have been documented within 5 miles of the proposed project area. No suitable habitat is present within the proposed project area. **Not Expected**
Vernal pool tadpole shrimp (*Lepidurus packardi*)	FE	Vernal pool tadpole shrimp is found in vernal pools in the Central Valley and San Francisco Bay area. The vernal pools this species inhabit can contain a range of clear to highly turbid water and can vary in size.	The closest CNDDB occurrence for vernal pool tadpole shrimp is southeast of Albrae within the Don Edwards San Francisco Bay National Wildlife Refuge approximately 8 miles away. No suitable habitat for vernal pool tadpole shrimp is present in the proposed project area. **Not Expected**
Fish			
Longfin smelt (*Spirinchus thaleichthys*)	FC CT CSSC	Longfin smelt is found in open waters of estuaries, mostly in the middle or bottom of the water column. It prefers salinities of 15 to 30 parts per thousand, but it can be found in completely freshwater to almost pure saltwater.	One CNDDB occurrence for longfin smelt has been documented within 5 miles of the proposed project area. No suitable habitat for longfin smelt is present in the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Steelhead (Central California coast Distinct Population Segment) (*Oncorhynchus mykiss irideus*)	FT	Adult steelhead migrate from the ocean into streams in the late fall, winter, or early spring seeking out deep pools within fast moving water to rest prior to spawning. Steelhead spawn in shallow-water gravel beds.	No CNDDB records for steelhead have been documented within 5 miles of the proposed project area. Channelization and other flood control projects have drastically reduced fish habitat in the creeks within the proposed project area and no suitable steelhead habitat is present within the proposed project area. In addition, operations of tidal gates at the mouth of Matadero Creek and Adobe Creek likely limit steelhead passage in the project area. **Not Expected**
Tidewater goby (*Eucyclogobius newberryi*)	FE CE	Tidewater goby inhabits brackish shallow lagoons and lower stream reaches where the water is fairly still, but not stagnant. It prefers a sand substrate component for breeding, but is also found on rocky, mud, and silt substrates. Tidewater goby is found in waters with salinity levels between 2 and 27 parts per thousand.	No CNDDB occurrences of tidewater goby have been documented within 5 miles of the proposed project area. No suitable habitat for tidewater goby is present within the proposed project area. **Not Expected**
Amphibians			
California red-legged frog (CRLF) (*Rana draytonii*)	FT CSSC	CRLF is found in lowlands and foothills in or near permanent sources of deep water. It prefers shorelines with extensive vegetation since it disperses far during and after rain. Larvae require 11-12 weeks of permanent water for development.	Four CNDDB occurrences for CRLF have been documented within 5 miles of the proposed project area, including within Matadero Creek near Old Page Mill Bridge and Foothill Expressway. Suitable dispersal habitat for CRLF is present in the proposed project area especially in the pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillview Avenue. **Moderate Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
California tiger salamander (*Ambystoma californiense*)	FT CT CSSC	California tiger salamander are found in grasslands and open oak woodlands. Necessary habitat components for this species include California ground squirrel (*Otospermophilus beecheyi*) or gopher burrows for underground retreats and breeding ponds, such as seasonal wetlands, vernal pools, or slow moving streams that do not support predatory fish or frog populations.	Four CNDDB occurrences for California tiger salamander have been documented within 5 miles of the proposed project area; however, most of these are from Lagunita Lake on the Stanford University Campus. Few, if any, tiger salamanders are likely to be present in the proposed project area due to lack of suitable habitat and the numerous barriers to dispersal, including curbs, steps, buildings, walls, and streets. The only area on the proposed project area with potentially suitable dispersal and upland habitat for this species is located in the pastureland habitat at the southern portion of the project area between Deer Creek Road and Hillview Avenue. **Low Potential**
Foothill yellow-legged frog (*Rana boylii*)	CSSC	Foothill yellow-legged frog are a highly aquatic species found in or near rocky streams in a variety of habitat, including valley and foothill hardwood, valley and foothill hardwood conifer, valley and foothill riparian, ponderosa pine, mixed conifer, coastal scrub, mixed chaparral, and wet meadow habitats.	No CNDDB occurrences for foothill yellow-legged frog have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present in the proposed project area. **Not Expected**
Reptiles			
Western pond turtle (WPT) (*Emys marmorata*)	CSSC	WPT requires permanent or nearly permanent bodies of water including ponds, marshes, rivers, streams, and irrigation ditches. It requires basking sites, such as submerged rocks, logs, open mud banks, or floating vegetation mats. This species also requires sandy banks or grassy open fields up to 0.5 kilometers from the water's edge for egg laying.	Two CNDDB occurrences for WPT have been documented within 5 miles of the proposed project area. No suitable aquatic habitat is present in the proposed project area. In addition, urbanization surrounding the proposed project area likely limits western pond turtle dispersal to the project area. **Low Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Alameda whipsnake (*Masticophis lateralis euryxanthus*)	FT CT	Alameda whipsnake is typically found in chaparral, northern coastal sage scrub, and coastal sage habitats. Recent telemetry data indicate that, although home ranges of Alameda whipsnakes are centered on shrub communities, they venture up to 500 feet into adjacent habitats, including grassland, oak savanna, and occasionally oak-bay woodland. Alameda whipsnakes require deep crevices or abundant rodent burrows for cover.	No CNDDB occurrences of Alameda whipsnake have been documented within 5 miles of the proposed project area. No suitable habitat for Alameda whipsnake is present in the proposed project area. **Not Expected**
San Francisco garter snake (*Thamnophlis sirtalis tetrataenia*)	FE CE	San Francisco garter snake is a highly aquatic species that is found in or near densely vegetated freshwater ponds with adjacent open hillsides where they can bask, feed, and find cover in rodent burrows.	No suitable aquatic habitat for San Francisco garter snake is present in the proposed project area. **Not Expected**
Birds			
Alameda song sparrow (*Melospiza melodia pusillula*)	CSSC	Alameda song sparrow is a resident of salt marshes bordering the south arm of the San Francisco Bay. It prefers tidally influenced habitats. This species is found in all relatively large marshes (e.g., Dumbarton Marsh, Palo Alto Baylands) and in most remnant patches of marsh vegetation along sloughs, dikes, and levees, including some highly disturbed and urbanized sites. Vegetation is required for nesting sites, song perches, and concealment from predators. In addition, Alameda song sparrow requires some upper marsh vegetation for nesting in order to ensure the nests remain dry during high tide.	Alameda song sparrow is a regular breeder and common throughout the year in Santa Clara County. Multiple CNDDB occurrences for Alameda song sparrow have been documented within 5 miles of the proposed project area. Although the project area does not support suitable foraging or nesting habitat, the marshlands north and east of the project area do provide suitable nesting and foraging habitat. As a result, Alameda song sparrow could fly through the project area adjacent to the marshland areas. **Low Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
American peregrine falcon (*Falco peregrinus anatum*)	CFP	American peregrine falcon uses steep cliffs and buildings for nesting. It forages over a variety of habitats, especially wetlands.	No CNDDB occurrences for American peregrine falcon have been documented within 5 miles of the proposed project area. Few, if any, ledges and cliffs are present in the proposed project area; however, numerous buildings are present for nesting. In addition, the marshland habitat to the north and east of the proposed project area provides suitable foraging habitat for peregrine falcon. **Low Potential**
Bank swallow (*Riparia riparia*)	CT	Bank swallow is a colonial nester and requires vertical banks and cliffs with fine-textured or sandy soils near streams, rivers, ponds, lakes, and the ocean for nesting. Nest sites consist of burrows dug into a vertical earthern bank to a depth of 18 to 36 inches.	No CNDDB occurrences for bank swallow have been documented within 5 miles of the proposed project area. No suitable habitat is present in the project area. **Not Expected**
Burrowing owl (BUOW) (*Athene cunicularia*)	CSSC	BUOW is found in open, dry annual grasslands and scrublands characterized by low-growing vegetation. It is dependent upon burrowing mammals, especially the California ground squirrel for nesting and wintering sites.	Multiple CNDDB occurrences for BUOW have been documented within 5 miles of the proposed project area, including at Byxbee Hills Park, which is a landfill currently being restored to grassland habitat, and Shoreline at Mountain View Park. This species has not been documented breeding near the proposed project area since the early 1900s; however, it has overwintered at Byxbee Hills Park as recently as 2014. Some marginal habitat is present in the pastureland habitat between Hillview Avenue and Deer Creek Road at the proposed project area. In addition, suitable foraging and breeding habitat is present within the disturbed marsh habitat in the vicinity of the RWQCP and suitable foraging habitat is present at Byxbee Hills Park near the RWQCP. **Moderate Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
California black rail (*Laterallus jamaicensis coturniculus*)	CT	California black rail is found in marshlands with unrestricted tidal influence (estuarine, intertidal, emergent, regularly flooded). It prefers areas dominated by pickleweed (*Salicornia virginica*), bulrushes (*Scirpus* sp.), matted salt grass (*Distichilis spicata*), and other marsh vegetation.	Occurrence of California black rail is very rare in Santa Clara County and there are no recent breeding records in the South San Francisco Bay. One CNDDB occurrence for California black rail has been documented within 5 miles of the proposed project area. Although the project area does not support suitable foraging or nesting habitat, the marshlands north and east of the project area provide suitable habitat. **Not Expected**.
California clapper rail (CCR) (*Rallus longirostris obsoletus*)	FT CT	CCR is found in tidal saltwater and brackish marshes traversed by tidal sloughs in the vicinity of the San Francisco Bay. It prefers tall stands of pickleweed and pacific cordgrass (*Spartina foliosa*), but they are also associated with gumplant (*Grindelia* sp.), saltgrass (*Distichlis spicata*), and alkali heath (*Frankenia grandifolia*).	CCR is a regular breeder and common year round resident in Santa Clara County. Multiple CNDDB occurrences for CCR have been documented within 5 miles of the proposed project area. Although the project area does not support suitable foraging or nesting habitat, the marshlands north and east of the project area provide suitable habitat; therefore, CCR could occur within 500 feet of construction activities at the RWQCP. **Low Potential**.
California least tern (*Sternula antillarum browni*)	FE CE	California least tern forages primarily in shallow estuaries or lagoons where small fish are abundant. It nests in loose colonies in areas relatively free of human or predatory disturbance on bare or sparsely vegetated, flat substrates in sand beach, alkali flat, or landfill habitats near shallow-water feeding areas.	Three CNDDB occurrences for California least tern have been documented in the salt pond habitat within 5 miles of the proposed project area. However, no suitable habitat for this species is present in the proposed project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Golden eagle (*Aquila chrysaetos*)	CFP BGEPA	Golden eagle is found in rolling foothills and mountain terrain, wide arid plateaus deeply cut by streams and canyons, open mountain slopes, cliffs, and rock outcrops.	No CNDDB occurrences of golden eagle have been documented within 5 miles of the proposed project area. No suitable habitat for this species is present on the proposed project area; however, the foothills adjacent to the southern portion of the proposed project area could support this species. As a result, this species could fly through the southern portion proposed project area. **Low Potential**
Long-eared owl (*Asio otus*)	CSSC	Long-eared owl frequents dense, riparian and live oak thickets near meadow edges, as well as nearby woodland and forest habitats. At higher elevations, it is also found in dense conifer stands.	One CNDDB occurrence for long-eared owl has been documented within 5 miles of the proposed project area. No suitable habitat is present in the proposed project area. **Not Expected**
Northern harrier (NOHA) (*Circus cyaneus*)	CSSC	NOHA is predominantly found in grassland and wetland communities; however, it uses various habitats. It nests on the ground in shrubby vegetation, usually at marsh edges.	Occurrence of NOHA is fairly common in Santa Clara county throughout the year. Three CNDDB occurrence of NOHA has been documented within 5 miles of the proposed project. No suitable nesting habitat is present at the project area; however, some suitable foraging habitat is present within the pastureland habitat at the southern portion of the proposed project area. In addition, the marshland areas north and east of the project area contain suitable nesting and foraging habitat for NOHA. Therefore, NOHA could fly through the project area. **Moderate Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Saltmarsh common yellowthroat (SMCY) (*Geothylpis trichas sinuosa*)	CSSC	SMCY nests and forages in fresh and saltwater marshes and seasonal wetlands. It breeds on the ground or up to 8 centimeters off the ground under the cover of dense shrubs and emergent aquatic vegetation.	Multiple CNDDB occurrences of SMCY have been documented within 5 miles of the proposed project area, including one at the junction of Mayfield Slough and Matadero Creek. No suitable nesting habitat is present in the proposed project area; however, the marshland areas north and east of the project area contain suitable foraging and nesting habitat. As a result, SMCY could fly through the project area or forage in the project area in areas adjacent to marshland habitat. **Moderate Potential**
Short-eared owl (*Asio flammeus*)	CSSC	Short-eared owl forages in in open, treeless areas, such as marshes and grasslands, with elevated sites for perches and dense vegetation for roosting and nesting.	No CNDDB occurrences for short-eared owl have been documented within 5 miles of the proposed project area. No suitable habitat is present in the proposed project area. **Not Expected**
Swainson's hawk (*Buteo swainsoni*)	CT	Swainson's hawk breeds in grasslands with scattered trees, juniper-sage flats, riparian areas, savannahs, and agricultural lands. It requires adjacent suitable foraging areas such as grasslands or agricultural fields such as alfalfa or grain fields with suitable rodent populations.	No CNDDB occurrences for Swainson's hawk have been documented within 5 miles of the proposed project area. No suitable nesting or foraging habitat is present at the proposed project area. **Not Expected**
Tricolored blackbird (*Agelaius tricolor*)	CSSC	Tricolored blackbird nests in or near open water in emergent wetland vegetation, especially in cattails (*Typha* sp.), but also in trees and shrubs. This species forages where insect prey is abundant, such as in croplands, grassy fields, flooded lands, and along edges of ponds.	No CNDDB occurrences for tricolored blackbird have been documented within 5 miles of the proposed project area. No suitable nesting habitat is present in the proposed project area; however, the pastureland at the southern portion of the proposed project area provides limited foraging habitat for this species. **Low Potential**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Western snowy plover (*Charadrius alexandrines nivosus*)	FT CSSC	Western snowy plover is found on sandy beaches, salt pond levees, and shores of large alkali lakes. It needs sandy, gravelly, or friable soils for nesting.	Two CNDDB occurrences for western snowy plover have been documented in the marshland habitat within 5 miles of the proposed project area. However, no suitable habitat for this species is present in the proposed project area. **Not Expected**
White-tailed kite (*Elanus leucurus*)	CFP	White-tailed kite nests in rolling foothills or valley margins with scattered oaks and river bottomlands or marshes next to deciduous woodland. It forages in open grasslands, meadows, or marshes with perching sites.	No CNDDB occurrences for white-tailed kite have been documented within 5-miles of the proposed project area. However, some suitable foraging and nesting habitat is present within the pastureland habitat at the southern portion of the proposed project area. In addition, the marshland areas north and east of the project area contain suitable nesting and foraging habitat for this species. **Low Potential**
Mammals			
American badger (*Taxidea taxus*)	CSSC	American badger is rare in western San Francisco Bay area. It occurs in grasslands and open stages of forest and scrub habitats with friable soils and good prey base of burrowing rodents.	No CNDDB occurrences for American badger have been documented within 5 miles of the proposed project area since 1981. No suitable habitat for this species is present in the project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Pallid bat (*Antrozous pallidus*)	CSSC	Pallid bat is uncommon, especially in urban areas. This species roosts in caves and large trees and forages in grasslands and oak savannah.	Two CNDDB occurrence for pallid bat have been documented within 5 miles of the proposed project area; however, these records are from 1945 and 1951. The proposed project area is mostly urban; therefore, limited suitable habitat is present in the project area for this species. However, pallid bat could forage and roost at the project area in the trees and bridges at the Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street. In addition, this species could forage at the southern portion of the project area in the pastureland between Deer Creek Road and Hillview Avenue. **Low Potential**
San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens*)	CSSC	San Francisco dusky-footed woodrat is found in forest and scrub habitats of moderate canopy and moderate dense understory.	One CNDDB occurrence for San Francisco dusky-footed woodrat has been documented within 5 miles of the proposed project area along Los Trancos Creek near the intersection of Interstate 280 and Alpine Road. Limited suitable habitat is present in the proposed project area for this species along Matadero Creek near Hillview Avenue. No woodrat houses were observed during the biological survey in November 2014. **Low Potential**
Saltmarsh harvest mouse (*Reithrodontomys raviventris*)	FE CE	Saltmarsh harvest mouse is only found in saline emergent wetlands in the San Francisco Bay and its tributaries. It uses pickleweed as its primary cover. It also uses non-submerged, salt-tolerant vegetation for escape during extremely high tides.	Multiple CNDDB occurrences for saltmarsh harvest mouse have been documented in the marshland habitat within 5 miles of the proposed project area. However, no suitable habitat for this species is present in the proposed project area. **Not Expected**

Species Name	Federal, State, and CNPS Listing Status[1]	Habitat Preferences, Distribution Information, and Additional Notes	Potential to Occur
Saltmarsh wandering shrew (*Sorex vagrans halicoetes*)	CSSC	Saltmarsh wandering shrew is most frequently found in salt marshes that provide dense cover and have abundant sources of invertebrates for food and continuous ground moisture.	Two CNDDB occurrences for saltmarsh wandering shrew have been documented in the marshland habitat within 5 miles of the proposed project area. However, no suitable habitat for this species is present in the proposed project area. **Not Expected**
Townsend's big-eared bat (*Corynorhinus townsendii*)	CPT CSSC	Townsend's big-eared bat roosts in caves, mines, and large trees. It forages within woodlands and along stream edges. This species is extremely sensitive to human disturbance.	Two CNDDB occurrences for Townsend's big-eared bat have been documented within 5 miles of the proposed project area. The proposed project area is mostly urban; therefore, limited suitable habitat is present in the project area for this species. However, this species could forage and roost at the project area in the trees and bridges at the Adobe Creek crossing near Middlefield Road, the Barron Creek crossing near Cowper Street, and the Matadero Creek crossing near Cowper Street. **Low Potential**

Notes: FE – Federal Endangered; FT – Federal Threatened; FC – Federal Candidate; BGEPA – Bald and Golden Eagle Protection Act; CE – State Endangered; CT – State Threatened; CPT – State Proposed Threatened; CFP – California Fully Protected; CSSC – California Species of Special Concern.

Appendix B - List of Observed Species

COMMON NAME	SCIENTIFIC NAME
Mammals	
Coyote (scat)	*Canis latrans*
California ground squirrel	*Otospermophilus beecheyi*
Audubon's cottontail	*Sylvilagus audubonii*
Botta's pocket gopher	*Thomomys bottae*
Birds	
Mallard	*Anas platyrhyncos*
Northern shoveler	*Anas clypeata*
Anna's hummingbird	*Calypte anna*
House finch	*Carpodacus mexicanus*
Rock pigeon	*Columba livia*
American crow	*Corvus brachyrhynchos*
Yellow-rumped warbler	*Dendroica coronata*
Snowy egret	*Egretta thula*
Brewer's blackbird	*Euphagus cyanocephalus*
California gull	*Larus californicus*
Ring-billed gull	*Larus delawarensis*
Song sparrow	*Melospiza melodia*
House sparrow	*Passer domesticus*
California Towhee	*Pipilo crissalis*
Ruby-crowned kinglet	*Regulus calendula*
Black Phoebe	*Sayornis nigricans*
Mourning dove	*Zenaida macroura*
Reptiles	
Western fence lizard	*Sceloporus occidentalis*

Appendix C – Representative Photographs

Photo 1: Embarcadero Way along the southern perimeter of the Regional Water Quality Control Plant (RWQCP), facing east.

Photo 2: Marshland habitat along Embarcadero Road adjacent to the north side of the RWQCP, facing north.

Title: Site Photographs – Palo Alto Recycle Project **Date:** November 2014

Site: Palo Alto, California

Photo 3: Adobe Creek crossing along West Bayshore Road, facing southeast.

Photo 4: Adobe Creek crossing along East Meadow Drive, facing north.

Title:	Site Photographs – Palo Alto Recycle Project	**Date:**	November 2014
Site:	Palo Alto, California		MIG

Photo 5: Adobe Creek crossing along Middlefield Road, facing northwest.

Photo 6: Representative developed habitat along the proposed project alignment, facing east.

Title:	Site Photographs – Palo Alto Recycle Project	**Date:**	November 2014
Site:	Palo Alto, California		MIG

Photo 7: Barron Creek crossing along Cowper Street, facing southwest.

Photo 8: Matadero Creek crossing along Cowper Street, facing southwest.

Title: Site Photographs – Palo Alto Recycle Project **Date:** November 2014

Site: Palo Alto, California

Photo 9: Proposed Booster Pump Station location at Mayfield Soccer Fields on the corner of El Camino Real and Page Mill Road.

Photo 10: Matadero Creek crossing along Hillview Avenue, facing west.

Photo 11: Matadero Creek crossing at Foothill Expressway, facing south.

Photo 12: Pastureland habitat between Deer Creek Road and Hillview Avenue, facing west.

Title: Site Photographs – Palo Alto Recycle Project **Date:** November 2014

Site: Palo Alto, California

Photo 13: Oak trees within pastureland habitat between Deer Creek Road and Hillview Avenue, facing northeast.

Appendix K – Cultural Resources Assessment Report

CULTURAL RESOURCES ASSESSMENT REPORT
Palo Alto Recycled Water Facility Project
Palo Alto, Santa Clara County, California

PREPARED FOR:

RMC WATER AND ENVIRONMENT
2290 North First Street, Suite 212
San Jose, CA 95131

PREPARED BY:

WILLIAM SELF ASSOCIATES, Inc.
PO Box 2192
Orinda, CA 94563
(925) 253-9070

WSA

February 2015

Confidential - Not for Public Distribution

CULTURAL RESOURCES ASSESSMENT REPORT
Palo Alto Recycled Water Facility Project
Palo Alto, Santa Clara County, California

PREPARED BY:

Allen Estes, Ph.D., Nazih Fino, M.A.,

CONTRIBUTORS TO EARLIER VERSIONS OF THE REPORT
Eric Strother M.A., RPA, Paul Farnsworth, Ph.D., RPA,
Drew Bailey B.A., and Melinda Hickman M.A., RPA

SUBMITTED BY:

James Allan Ph.D. Principal Investigator

Project Number 2014-101
Report Number 2014-67

February 2015

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Cover Photo: 1876 Thompson and West Historic Atlas Map of Santa Clara County, California

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Management Summary

RMC Water and Environment (RMC) has contracted with William Self Associates, Inc. (WSA) to conduct a cultural resource assessment of the Palo Alto Recycled Water Facility Project. The proposed project is located in Township 6 South, Range 3 West, Section 11, and Township 6 South, 2 West, Section 8 as depicted on the Palo Alto, California 7.5' USGS topographic quadrangle maps.

A records search conducted on October 23, 2014 at the Northwest Information Center at Sonoma State University (NWIC) indicated that one previously recorded resource (a historic railroad, P-43-000928) crosses the project APE and 15 other previously recorded archaeological sites are located within 1/4-mile of the project area. A total of 91 cultural resource studies have been conducted within 1/4 mile of the project APE. Twenty-two studies include or cross some portion of the project components, while the remaining 69 studies do not include project components but have been conducted within ¼-mile of the project's area of potential effects (APE).

WSA contacted the Native American Heritage Commission (NAHC) with a request for information on sacred sites or traditional cultural properties within the project area, and for a list of interested Native American representatives. No information on sacred sites or traditional cultural properties was obtained from either the NAHC or from any of the interested Native American representatives, whom WSA contacted by letter.

WSA created a formal vertical APE map. In order to prepare this figure and the related analysis of the relationship between construction disturbance and archaeological sensitivity, WSA created an archaeological sensitivity model based on soil type, slope, and distance to nearest water that calculates areas of high, medium and low archaeological potential within the project area. Seven areas of either high or high-to-moderate archaeological sensitivity were identified along the project alignments, most of which occur at creek crossings.

WSA conducted pedestrian archaeological surveys of the proposed project area on October 24, 2014. No new archaeological sites were identified during the survey. The proposed site of the recycled water facility is located entirely along developed residential and commercial regions within the City of Palo Alto, which are paved with concrete or recently landscaped. No cultural materials were identified within the proposed project area. No adverse impacts are anticipated during the construction of the facility. Because of the high archaeological sensitivity of portions of the project area, subsurface monitoring is recommended for these areas.

1.0 Introduction

1.1 National Historic Preservation Act Compliance

The City of Palo Alto is the Lead Agency for the project, which is applying for Title XVI grant monies from United States Bureau of Reclamation (Reclamation). Through the Title XVI program, Reclamation identifies and investigates opportunities to reclaim and reuse wastewaters and naturally impaired ground and surface water in the 17 Western States and Hawaii. Authorization of Title XVI funding necessitates compliance with Section 106 of the National Historic Preservation Act (NHPA) as an "undertaking." The City of Palo Alto is also applying for State Revolving Fund (SRF) funding from the State Water Resources Control Board (SWRCB). Because this program is partially funded by the United States Environmental Protection Agency (EPA) and is subject to federal environmental regulations, it must also comply with federal cross-cutting regulations, including compliance with the NHPA. The present cultural assessment report will serve as the historic properties inventory for purposes of complying with Section 106 of NHPA and the implementing regulations found at 36 CFR Part 800.

1.2 Cultural Resources Assessment Report

William Self Associates, Inc. (WSA) conducted the cultural resources assessment for the Project under contract to RMC, who is coordinating all of the environmental studies for the Project. This Cultural Resources Assessment Report (CRAR) is a revision of the 2009 version. To complete this revision, WSA scope of work included:

- Develop an approved vertical Area of Potential Effects (APE) map and the related analysis of the relationship between construction disturbance and a more detailed discussion of archaeological sensitivity and the likelihood of encountering buried archaeological sites within the project alignment.
- Consult with the California Historical Resources Information System, Northwestern Information Center (NWIC) at Sonoma State University to conduct a new records search of the project area in order to identify known archaeological sites and previous surveys in or near the project area. Review all archaeological site records for sites within the limits of the archaeological APE. Review of additional data on the history and prehistory of the APE on file at WSA, and other sources as necessary.
- Contact the Native American Heritage Commission (NAHC) in Sacramento to describe the project and request a listing of local, interested Native American representatives. Request the NAHC to review their Sacred Lands file for information on traditional or cultural lands within the vicinity of the project area. Contact the individuals or tribal members on the contact list and solicit comments regarding individual knowledge about sacred sites or traditional lands within the project area.

- In accordance with CEQA Sections 15064.5 and 15126.4 and NHPA Section 106, as a means of evaluating the potential impacts to archaeological resources, WSA's 36 CFR 61-qualified archaeological staff conducted a pedestrian archaeological survey of the archaeological APE.

1.3 Background

The Palo Alto Recycled Water Project (Project) is an extension of the City of Palo Alto Water Reuse Program. Phase 1, completed in 1980, serves the Palo Alto Golf Course, Emily Renzel Marsh, Greer Park, and the Regional Water Quality Control Plant (RWQCP). Phase 2, completed in 2009, is the Mountain View Recycled Water project, which serves the City of Mountain View. The proposed City of Palo Alto Recycled Water Project (Project) would serve customers in the City of Palo Alto, potentially including Alta Mesa Memorial Park, Stanford Research Park, and others. The project area extends southeast from its connection to the existing system, along highway 101 near Adobe Creek, approximately four miles southwest through the City of Palo Alto, in Santa Clara County (Figures 1 and 2).

1.4 Project Description

The Project proposes the construction of a recycled water pipeline and associated facilities to provide an alternative water supply for non-potable uses. The proposed Project would involve the construction of approximately 5 miles of 12- to 18-inch pipes, approximately 5 miles of 6- to 10-inch lateral pipelines to over 50 use sites, an up to 1,500 square-foot booster pump station along the proposed pipeline, and an up to 1,600-square-foot pump station at the RWQCP. The Project would initially serve approximately 900 acre-feet per year (AFY) of recycled water, primarily to the Stanford Research Park Area. Future extensions could serve Stanford University and Los Altos Hills, as well as provide a loop by making a second connection to the Phase 2 Mountain View Project. These future extension projects would undergo project specific environmental review by the appropriate lead agency as they are proposed. The predominant use of recycled water for this Project is landscape irrigation. Some industrial use, such as toilet flushing, commercial and light industrial cooling towers, could also be included at a later date. The locations of the proposed Project components are shown in Figure 3.

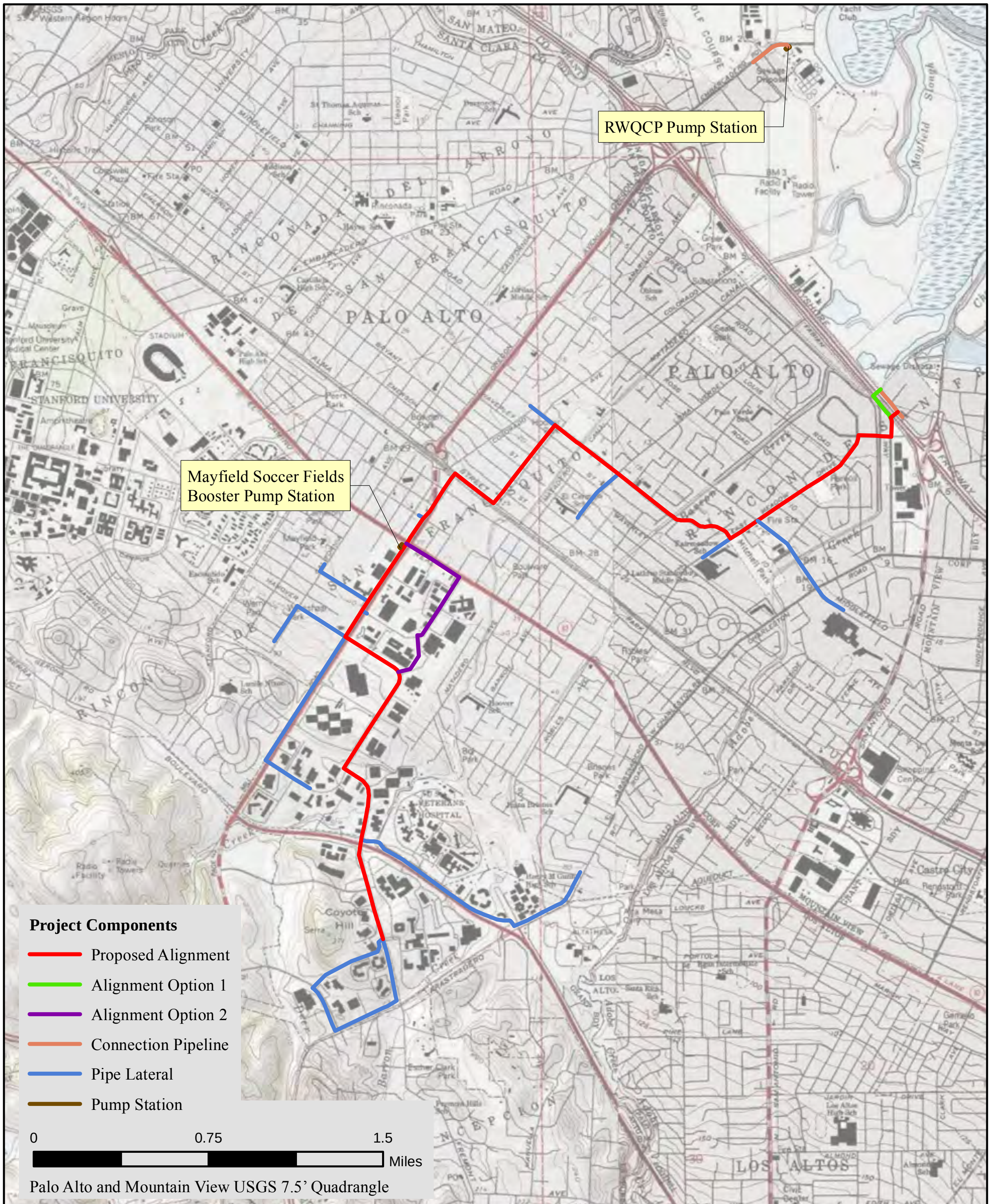
Pipelines -- the proposed distribution system consists of the "backbone" pipeline and lateral pipelines. The backbone pipeline would be located in urban areas, along existing road rights-of-way (refer to Figure 3). The proposed backbone pipeline alignment would begin in the north with a connection point to the existing 24-inch recycled water pipeline that was constructed as part of the Mountain View Project, in the vicinity of East Bayshore Road and Corporation Way. The pipeline would cross under US-101, and run along Fabian Way to East Meadow Drive where it would cross Adobe Creek. The pipeline would run along East Meadow Drive across Middlefield Road, and then continue along East Meadow Drive, Cowper Street, and El Dorado Avenue to Alma Street, along Alma Street to Page Mill Road, and along Page Mill Road to El Camino Real.

WSA

Project Vicinity Map

Figure 1
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA

WSA	Project Area Map	Figure 2 RMC Palo Alto Recycled Water Facility Project Palo Alto, CA



WSA	Project Location	Figure 3 RMC Palo Alto Recycled Water Facility Project Palo Alto, CA

The pipeline would continue across El Camino Real, along Page Mill Road to Hanover Street, and along Hanover Street and Hillview Avenue to Arastradero Road. Two pipeline alignment options could potentially replace segments of the proposed backbone pipeline alignment depending on constructability and design considerations, as shown in Figure 3. Roads included in the backbone pipeline alignment, including the options, are detailed in Table 1.

Table 1: Proposed backbone pipeline alignment

Alignment Location	Starting Cross Street	Ending Cross Street	Proposed Construction Method at Crossings
Proposed Backbone Pipeline Alignment			
Under US-101	E. Bayshore Rd. at Corporation Way	Fabian Way	Trenchless under 101
Fabian Way	West Bayshore Road	East Meadow Drive	Open-Cut1
East Meadow Drive	Fabian Way	Cowper Street	Open-Cut; Potential trenchless[2] section across Adobe Creek Bridge
Cowper Street	East Meadow Drive	El Dorado Avenue	Open-Cut; Potential trenchless sections across Barron Creek Bridge and Matadero Creek Bridge
El Dorado Avenue	Cowper Street	Alma Street	Open-Cut
Alma Street	El Dorado Avenue	Page Mill Road	Open-Cut
Page Mill Road	Alma Street	Hanover Street	Open-Cut; Trenchless section under railroad crossing; Potential trenchless section under El Camino Real
Hanover Street	Page Mill Road	Hillview Avenue	Open-Cut
Hillview Avenue	Hanover Street	Arastradero Road	Open-Cut; Potential trenchless section across SFPUC Easement and Foothill Expressway
Proposed Pipeline Alignment Option 1			
Adobe Creek	US-101	West Bayshore Road	Trenchless (hang from the bridge)
West Bayshore Road	Adobe Creek	Fabian Way	Open-Cut
Pipeline Alignment Option 2			
El Camino Real	Page Mill Road	Hanson Way	Open-Cut
Palo Alto Square Parking	Hanson Way	Hanover Street	Open-Cut

[1] The open-cut construction method involves long, narrow excavations in the ground to accommodate the placement of the pipelines. An alternate construction method to open-trench is Horizontal Directional Drilling. Both types of construction methods are described in Section 2.4 below.
[2] All of the bridge crossings would be trenchless (constructed with the pipe attached to the side of the bridge or installed underneath the bridge). The construction method has not been finalized. Neither method would require work to be done in the creeks.

Lateral pipeline alignments would run along existing side streets from the proposed backbone pipeline alignment or alignment options to serve individual users as shown in Figure 3.

Booster pump station -- the booster pump station would be constructed as part of the proposed Project to maintain a minimum delivery pressure of 65 pounds per square inch (psi) for end users. The proposed booster pump station would be located at 2700 El Camino Real, on the southeast corner of the Page Mill Road and El Camino Real intersection at the Mayfield Soccer Fields. The site is on the proposed pipeline alignment and located in a strategic area for delivering recycled water to the majority of demands along the pipeline. The park is owned by Stanford and leased to the City of Palo Alto.

The proposed booster pump station would be constructed below grade at the parking lot because of the prominent visual location and to avoid effects on existing recreational uses. The pump station would have a peak flow rate of 2,860 gallons per minute (gpm), which would require a total installed horsepower (hp) of 400 hp, including standby pumps. The footprint would be approximately 50 x 30 feet (1,500 square feet).

RWQCP pump station -- The Phase 2 Project planning study and hydraulic model assumed that adequate pumping capacity would be available at the RWQCP to maintain minimum delivery pressure for end users. The RWQCP has since built a pump station at the facility to deliver 6.24 mgd of recycled water flows to Phase 2 users. These pumps were not designed to provide capacity for the Palo Alto recycled water project during peak flow conditions. Phase 2 pump station construction was completed in 2009.

To accommodate the Project and achieve the minimum acceptable pressure at the Phase 2 connection point during peak flows, additional pumping capacity would be necessary at the RWQCP. The RWQCP pump station would have a capacity of 4.8 mgd (3,310 gpm) requiring a 350 hp facility. Several preliminary siting options have been identified for the pump station. The final site would be determined during detailed design. It is possible that a pump station could be located elsewhere on the north side of the plant, but it would be located entirely within the plant footprint and would avoid removal of trees. Options include the following:

1. Installation of the additional pump in the basement of the existing administrative building and relocation of the existing marsh pump to the contact tank outlet box. No new piping is needed for this option to connect to the recycled water system, as existing pipes are in place.

2. Construction of the pump station within the existing, empty chlorine contact tank in the northwestern portion of the plant. A new pipeline would be needed to connect to the existing recycled water system. The pipeline would likely be routed on paved ground

through the northern entrance of the plant (located northeast of the chlorine tank), then along Embarcadero Road to its connection with the existing 30-inch pipeline on Embarcadero Way.

3. Construction of the pump station adjacent to and northeast of the existing contact tank. Similar to the above option, a new pipeline would be needed.

If located outside existing structures, the pump station could require a footprint of up to 40 feet x 42 feet (1,680 square feet) and would be up to 12 feet tall and enclosed or covered. While this would be located above ground and excavation would be 5 to 6 feet, the pump cylinders would likely be 20 foot down for the pump station that is located outside existing structures. Note that excavation would not be required for the other options within existing structures. This structure would be subject to the City's design review to address all aesthetic concerns.

1.2 Project Construction

The following section outlines the pipeline installation techniques under consideration for use in the Project. Final plans have not been completed and one or more of the techniques described below may be used in the construction of the Project.

All pipeline construction would occur within public roadways. An easement from the California Department of Transportation (Caltrans) would be required to construct the pipeline across and along US-101. An easement from Santa Clara Valley Water District (SCVWD) would be required to cross all creeks and the SCVWD rights-of-way. This includes easements to install hanging pipes on bridges. A Peninsula Corridor Joint Powers Board (JPB) Property Access Agreement may be required for the railroad crossings. Construction of the backbone and lateral pipelines would generally consist of open-cut construction, except at crossings (e.g., creek, railroad, or road). A variety of trenchless construction methods could be employed at these locations. Alternatively, horizontal directional drilling (HDD) may be used along the entire alignment, except at pipeline tie-ins (i.e., connection to existing pipelines). A description of each technique is described below.

Open-Cut Pipeline Construction -- Open-cut construction (also referred to as open trench with shoring or cut-and-cover) is the proposed option for installing the majority of the pipeline along existing roadways. The open-cut trench would be approximately three feet wide and approximately four to eight feet deep. Shoring may be required to provide trench stability. Where this method is used within roadways, the existing pavement would be cut, removed and replaced during the course of the construction. To prevent discharge into creeks, requirements for erosion control would be included in construction specifications for all construction in the vicinity of creeks.

Pipeline construction would typically require a minimum of one lane of traffic and the adjacent shoulder and/or bike lane (if they exist), resulting in a construction corridor approximately 20 to 30 feet wide. It is expected that open trench construction within paved roadways would proceed at the rate of approximately 200 to 300 feet per day. Given the rate of construction, pipeline installation would occur for a relatively brief period of time (at most a few days) at any one location along the pipeline alignment. Excavated trench materials would be side cast within approved work areas and reused as appropriate for backfill. After pipeline construction and installation is complete, the pavement would be restored to preconstruction conditions.

Trenchless Pipeline Construction -- Trenchless construction methods would be used for selected roadway, railroad, and creek crossings. Trenchless construction methods minimize the area of surface disruption required for pipeline installation and include: jack and bore, microtunneling, and HDD. Hanging pipes on existing bridge structures is another potential trenchless approach. Trenchless pipeline installation methods are described following a discussion of the crossings.

The proposed alignment, alignment options, and laterals would cross three creeks: Adobe Creek, Barron Creek, and Matadero Creek. The creek crossings would be constructed as follows:

- Adobe Creek. There are four proposed Adobe Creek crossings. The first crossing is associated with the proposed alignment on East Meadow Drive, west of US-101. The pipeline would be attached to the existing East Meadow Drive Bridge on the south side of the bridge or installed in the roadway on the bridge. The second crossing is associated with the Option 1 alignment, where the existing Adobe Creek crosses under US-101. The pipeline would be hung on the south side of the existing bridge. The third crossing is associated with a lateral pipeline on Middlefield Rd, which would require crossing Adobe Creek using trenchless techniques at the Middlefield Road bridge. The fourth crossing at Arastradero Road would involve a lateral pipeline crossing either above or below Adobe Creek, as the creek is culverted at this location.

- Barron Creek. The alignment crosses Barron Creek, which flows in a concrete channel, on the Cowper Street Bridge. The pipeline would either be installed attached to the downstream side of the bridge or installed in the roadway on the bridge. A lateral pipeline would be constructed at Miranda Avenue using trenchless techniques.

- Matadero Creek. There are two Matadero Creek crossings. At the Cowper Street crossing, a bridge crosses Matadero Creek, which flows in a concrete channel. The pipeline would either be installed attached to the downstream side of the bridge or installed in the roadway on the bridge. At the Hillview Avenue crossing, Matadero Creek flows through a 12-foot wide box culvert below the roadway. The pipeline would be installed in the roadway, above the culvert.

In addition to the creek crossings, a trenchless railroad crossing would occur on Page Mill Road between Alma Street and Park Boulevard. Another trenchless crossing may occur on Hillview Avenue at the intersection of Foothill Expressway to cross a San Francisco Public Utilities Commission (SFPUC) right-of-way. Trenchless construction may also be used to cross busy intersections, at Page Mill Road and El Camino Real, and Hillview Avenue and Foothill Expressway

Table 2: Trenchless creek and road crossings

Location	Crossing
Adobe Creek	US 101
	East Meadow Drive
	Middlefield Road[1]
	Arastradero Road[1]
Barron Creek	Cowper Street
	Miranda Avenue[1]
Matadero Creek	Cowper Street
	Hillview Avenue
Page Mill Road	Railroad crossing between Alma Street and Park Boulevard
	El Camino Real
Hillview Avenue	SFPUC easement at intersection of Foothill Expressway
	Foothill Expressway

Note: [1]Lateral pipeline

Bore and Jack Construction -- Bore and jack is a trenchless pipeline installation method that is often used for major roadway intersections and railroad crossings. Boring and jacking would involve the use of a hydraulic jack and auger stem (situated in a pit located at one end of the crossing) to simultaneously push a casing through the hole under the crossing while removing spoil from within the jacked casing. The pipeline is then installed in the casing. The jacking pit is excavated (and shored) with typical dimensions of 8 to 12 feet wide and 15 to 20 feet long. The depth would depend on the feature to be avoided (e.g., creek, railroad, or road) as well as the presence of any existing utilities underground. The typical depths of construction for this and other trenchless methods are shown in Table 3 below.

Table 3: Trenchless creek and road crossings with construction depths

Location	Range of Construction Depth (feet)
Connection Point on East Bayshore Rd.	4 – 6
Highway 101 Crossing (trenchless)	25 – 30
East Meadow Drive at Adobe Creek	15 – 17
Middlefield Rd at Adobe Creek	15 – 17
Cowper St at Barron Creek	12 – 14
Cowper St at Matadero Creek	8 – 10
Page Mill Road (railroad crossing)	4 – 20
Page Mill Road (El Camino Real crossing)	8 – 10
Page Mill Road	6 – 8

Hillview Ave. and Arastradero Rd.	4 – 8
Hillview Ave. at Matadero Creek	20 – 24
Hillview Ave. (Foothill Expy Crossing)	25
Miranda Ave. at Barron Creek	15 – 17
All other open cut segments, including laterals	4 – 8

Shoring, appropriate to the pit depth, would be used to secure the walls. In addition, the back wall of the receiving pit would need to be constructed so as to withstand the reactive forces from the jacking frame. An additional area of up to 2,000 square feet may be needed around the pit for temporary storage of pipe sections and for loading material removed from the bore. The receiving pit at the other end of the crossing would be smaller, encompassing approximately 100 square feet. Pits and work areas would be located within existing ROW and along streets, where appropriate. It would take an average of approximately one month to complete pipeline installation at a 40-foot concrete-lined creek crossing, such as Adobe Creek at US 101, using the boring and jacking technique. After pipeline construction and installation is complete, the work area would be restored to preconstruction conditions.

Microtunneling -- Microtunneling is a remotely controlled pipejacking process that provides continuous positive control of earth and groundwater pressures at the face of the excavation. Jacking pipes are pushed by a microtunneling boring machine (MTBM) into the ground from a jacking pit to a receiving pit on opposite sides of the crossing. The carrier or product pipe[1] may be jacked directly or installed inside an oversized casing in a separate operation.

A cutterwheel[2] excavates material at the face as the machine is jacked forward. The excavated material is mixed with clean slurry[3] and pumped to the surface for separation and muck removal. Microtunneling machines have a closed face, thus limiting the size of rock or other object that can be ingested. Most machines are only capable of handling cobbles and boulders less than or equal to 20 to 30 percent of the outside diameter of the shield. In addition, large quantities of smaller cobbles can stall a MTBM by clogging the crushing chamber with rocks before they can be crushed and ingested. Therefore, microtunneling is not a preferred method when large quantities of cobbles and boulders or other objects are anticipated.

Slurry pressure and mechanical face pressure are used to support the face of the excavation when ground conditions are loose or soft. In high groundwater conditions the slurry excavation system prevents inflow of water into the pipeline. Microtunneling is typically used in a wide variety of soil types, including rock and stable soils to loose, flowing, or otherwise unstable soils.

[1] The carrier or product pipe is the pipe that is being installed, in this case a recycled water pipeline.
[2] Cutter wheels or cutting wheels enable excavation of the drill head or end of the microtunneling machine through the ground.
[3] Slurry is used as a lubricant to reduce friction while drilling and provide support in the gaps between the edge of the drilling machine and the ground.

Microtunneling provides continuous control of line and grade by use of a guidance system and steering jacks. The guidance system usually consists of a reference laser mounted in the jacking shaft that transmits its beam onto a target mounted inside the articulated section of the MTBM. This information and other operational performance information are transmitted through wire cables to the MTBM control cabin at the surface where the MTBM is remotely controlled.

Jacking pits for microtunneling are typically 12 to 16 feet wide by 24 to 32 feet long (typical maximum approximately 500 square feet). Receiving pits are typically 12 to 16 feet square. Pit depths would vary depending on the feature being avoided as well as the presence of any existing utilities underground. The range of depths associated with construction is shown in Table 3 above. A work area (including the area of the pits) of up to 10,000 to 20,000 square feet is required at the jacking pit. Work area at the receiving pit can be smaller, but is typically a minimum of 8,000 square feet. Off-site staging areas can be used to reduce work areas at each shaft. Pits and work areas would be located within existing ROW and along streets, where appropriate. Pipeline installation at a 40-foot concrete-lined creek crossing using the microtunneling technique would take an average of approximately two months to complete. After pipeline construction and installation is complete, the work area would be restored to preconstruction conditions.

Horizontal Directional Drilling (HDD) -- HDD is a trenchless pipeline installation method that can be used for crossing major roadway intersections, creeks, and as an alternative to open-cut construction. HDD crossings are installed by using a drill rig tilted at the top at an angle of up to ten degrees from horizontal. The bore entry holes are drilled from the starting point to the destination point. In preparing the hole, a small diameter (3-inch wide) pilot hole is first drilled from the entry pit in a gentle arc from the drill rig to the completion hole on the other side of the area to be crossed. Alternatively, the pilot hole is drilled along a pre-determined horizontal and vertical alignment from the entry site to the exit site. This pilot hole can be guided using magnetic readings transmitted from the drill bit back to the drill rig.

After the initial hole is drilled, the final bore entry pit, approximately 10 feet square by approximately 8 feet deep, is constructed and is used as the collection point for Bentonite drilling mud and drill spoil. The pilot hole is then enlarged by pulling larger reamers, or reaming heads[4], from the pilot exit pit back towards the drilling rig. The pipeline is then pulled into place behind the last reamer head.

During the directional drill procedure, drilling mud is injected into the drill and recovered from the entry hole until the drill bit surfaces at the exit pit. Once the drill bit surfaces, the drilling mud is recovered at both the entry and exit hole, pumped into tanks and transported back to the

[4] Reamers are tools used to create accurate sized holes.

rig location for cleaning and eventual reuse. The drilling equipment and materials require a work area of approximately 2,500 square feet. An additional area of approximately 2,000 square feet is needed for loading materials removed from the bore. Pits and work areas would be located within existing ROW and along streets, where appropriate. Pipeline installation at a 40-foot concrete-lined creek crossing using HDD would take an average of three weeks to complete.

If HDD is used for the installation of the entire pipeline, then pits would be located throughout the pipeline alignment. The frequency of construction pits would vary depending on pipe size, existing underlying utilities, and other environmental conditions. Typically, for an 18-inch pipe, the construction pits would be located approximately every 500 to 1,000 feet due to the increased force necessary to install large pipes. Smaller pipe sizes would require less frequent pit locations because they can be installed in longer segments. Pipes would be installed at variable depths depending on existing underlying utilities, soil types, environmental constraints, entry and exit constraints, and bend radius of the installed product and drill pipe. Other pit depths would vary depending on the feature being avoided as well as the presence of any existing utilities underground. The range of depths associated with construction is shown in Table 3 above.

Installation of pipeline using HDD would proceed at the rate of approximately 100 feet per day for 18-inch pipe, and at greater rates for smaller pipe segments. Some pipeline installation would require construction in existing roadways.

Hanging on Existing Structures -- Hanging pipes from existing structures is a potential method for installing pipelines over creeks where existing bridges can provide structural support for the pipeline. No excavation would be required for placement of the hanging pipeline crossings, and no disruption of the creek channel would be required. The pipeline would be installed externally on the side or under the bridge. There would be no construction equipment within the wetted limits of the creek channels. Pipeline would be installed from the bridge where feasible; however, equipment may be on the banks of the channel or adjacent land in order to secure the pipeline to the bridge, but would not have to enter the wetted perimeter of the creeks.

US-101 Crossing -- As described above, two options to cross underneath US-101 include using trenchless construction technique under the proposed alignment and hanging from an existing bridge under Option 1. The precise option and the locations would be determined during design. If trenchless construction is employed, the pits could be located within any open area (e.g., on existing parking lots). Depending on the location, landscaped trees may be trimmed and/or removed to accommodate the pits and other activities in the work area. Existing parking spaces would be temporarily eliminated. Construction would require the City to work with the land owner to accommodate temporary loss of parking and disruption. If the pipeline is hung from the existing bridge on the south side of Adobe Creek, then construction would likely occur during the non-rainy season (April 16 through October 14), when the Adobe Creek Pedestrian Path is open. However, installation of the proposed pipeline would require temporary closure of the existing path for several days to a week.

Connection to the Existing 24-inch Recycled Water Pipeline (Mountain View Project) -- The proposed pipeline would be connected to the existing 24-inch pipeline along East Bayshore Road at the intersection with Corporation Way. Depending on the precise location of the Highway 101 crossing, a short connection pipeline may need to be constructed; this connection pipeline would be constructed via open cut construction. Because of this stub out, a system shutdown is not required when the proposed pipeline is connected to the existing pipeline.

Pump Station Construction -- The booster pump station at Mayfield Soccer fields would require cutting the pavement, excavation and shoring, placement of the structure underground, and refinishing the pavement, and surrounding sidewalks / curb, as applicable. After the structure has been constructed, electrical equipment (e.g., machinery control consoles, panels, switchboards, lighting) would be installed and other site preparation (installing conduits and cables) would occur. Approximately five crewmembers would be needed for construction.

The pump station proposed at the RWQCP would be either installed within existing structures or located outside, adjacent to the existing, empty contact tank. Regardless of the location, it would be constructed entirely within existing City property. If located outside of existing structures, construction would involve excavation, installation of the pump station, electrical equipment, and erection of an enclosure if necessary. If the structure is located within an existing structure, then work would consist of installation of the pump. Relocation of the existing marsh pump may be necessary if the proposed pump is installed within the basement of the administration building. The connection pipeline segment along Embarcadero Road would be installed via open trench construction. Construction of each pump station is estimated to take approximately six months.

1.3 Project Location and Area of Potential Effects

The project is located in Township 6 South, Range 3 West, Section 11, and Township 6 South, 2 West, Section 8 as depicted on the Palo Alto, California 7.5-minute USGS topographic quadrangle maps.

The Area of Potential Effects (APE) assumes a 5-foot wide trench for all open cut trenching. The dimensions of all other components are based on the project description above. All depths are below ground surface and all maximum depths for each component as described in the project description above are used for the vertical APE. The vertical APE depicts the maximum potential impacts from project construction based on the information provided in the project description above. The vertical APE is presented in Figure 4-Maps 1-7.

2.0 Setting

2.1 Environmental Setting

The project area is located along the Palo Alto Baylands on the southeast portion of the San Francisco Peninsula, which lies along the southwest boundary of the San Francisco Bay. The project area ecology, though heavily impacted by urban and industrial development, is coastal littoral, which consists of land strips along the coast that are characterized by a series of microenvironments including estuaries, bays, marshes, and grassy terraces (Chartkoff and Chartkoff 1984). The eastern portion of the project area, near Highway 101, is an area of historic fill that extends eastward into the Palo Alto Baylands. The Palo Alto Airport and Municipal Golf Course are located approximately two miles northeast of the project area. Byxbee Park and the Palo Alto Baylands Nature Preserve, consisting primarily of restored marshes, are located approximately 1½-miles northeast. The project area extends approximately four miles southeast, through the easternmost portion of the city of Palo Alto, and ends within one mile of Highway 280, with the Los Altos Hills to the south and Portola Valley to the west.

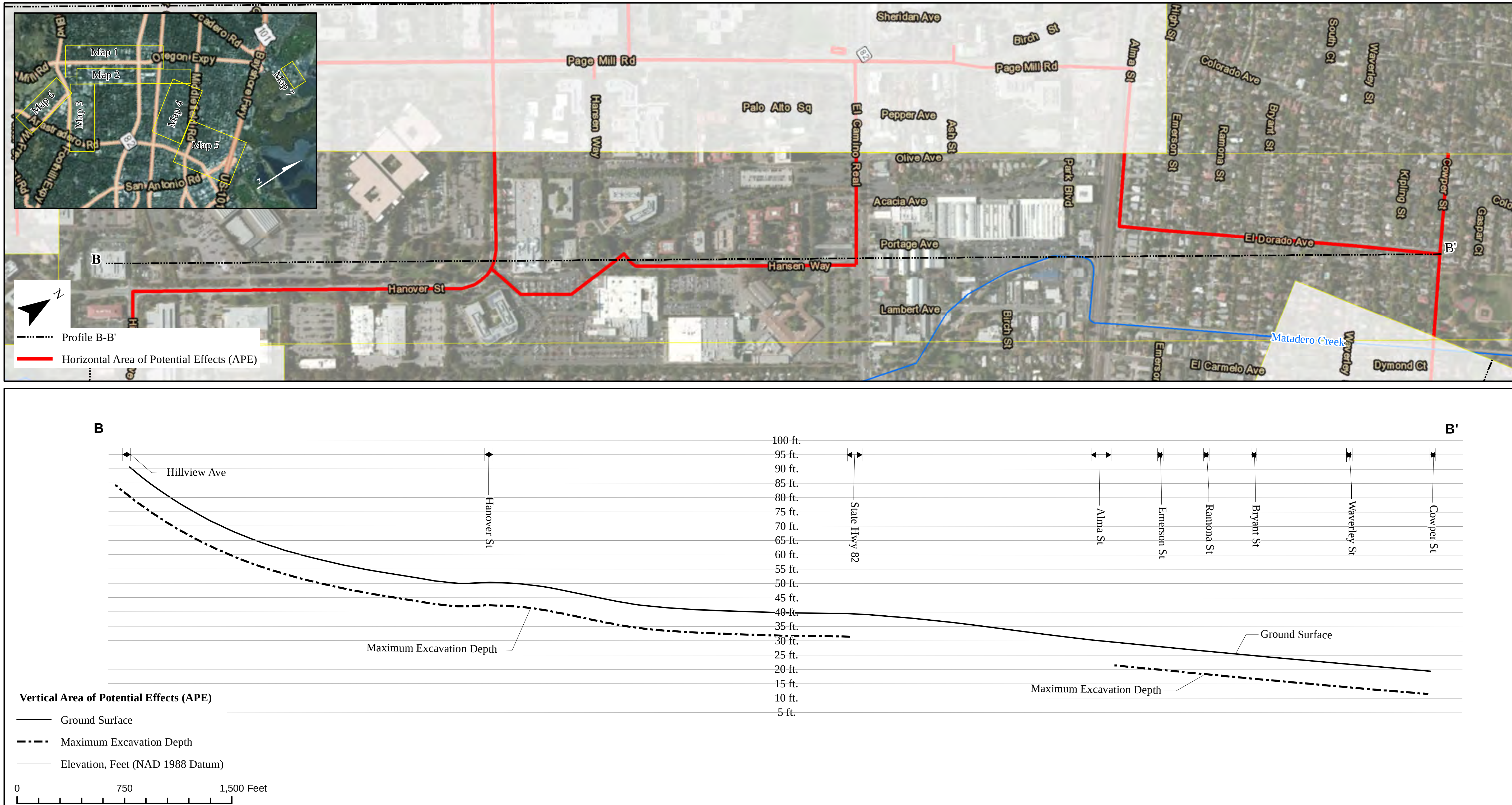
The climate of the project area is Mediterranean; mild, rainy winters, and hot, dry summers. Annual precipitation in the area is 15 inches, with rainfall concentrated in the fall, winter, and spring. The San Francisco Peninsula's proximity to the Pacific Ocean provides for mild temperatures throughout the year. Winter temperatures vary from an average high of 57.2°F to an average low of 37.7°F; summer temperatures vary from an average high of 78.4°F to an average low of 54.4°F.

Prior to Euroamerican contact, the Native Americans used fire to manage native flora and fauna, maintaining grassland and chaparral by periodic burning. In prehistoric times, animals such as pronghorn sheep, antelope, tule elk, mule deer, black-tail deer, and grizzly bear occupied the area. Today, animal life within the region is similarly diverse but favors small, herbivorous mammals, especially voles, pocket gophers, ground squirrels, and pocket mice. The larger, open areas of the surrounding hills are home to some larger animals including deer, coyote, rabbit, skunk, opossum, raccoon, and a number of birds including red-tailed hawks and turkey vultures.

WSA

Archaeological Horizontal and Vertical Area of Potential Effects

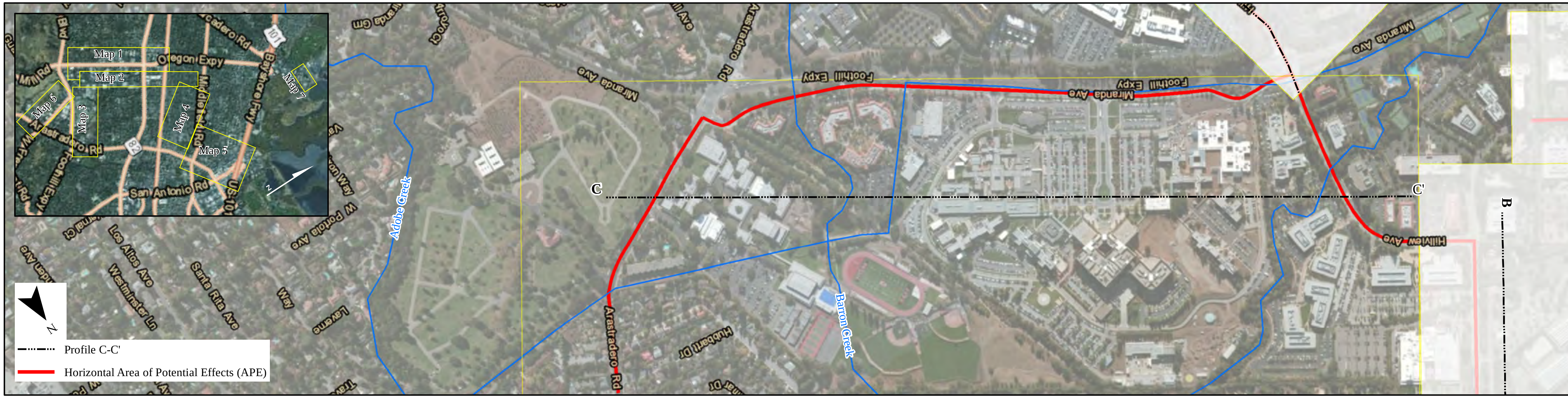
Figure 4
Map 1 of 7
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA

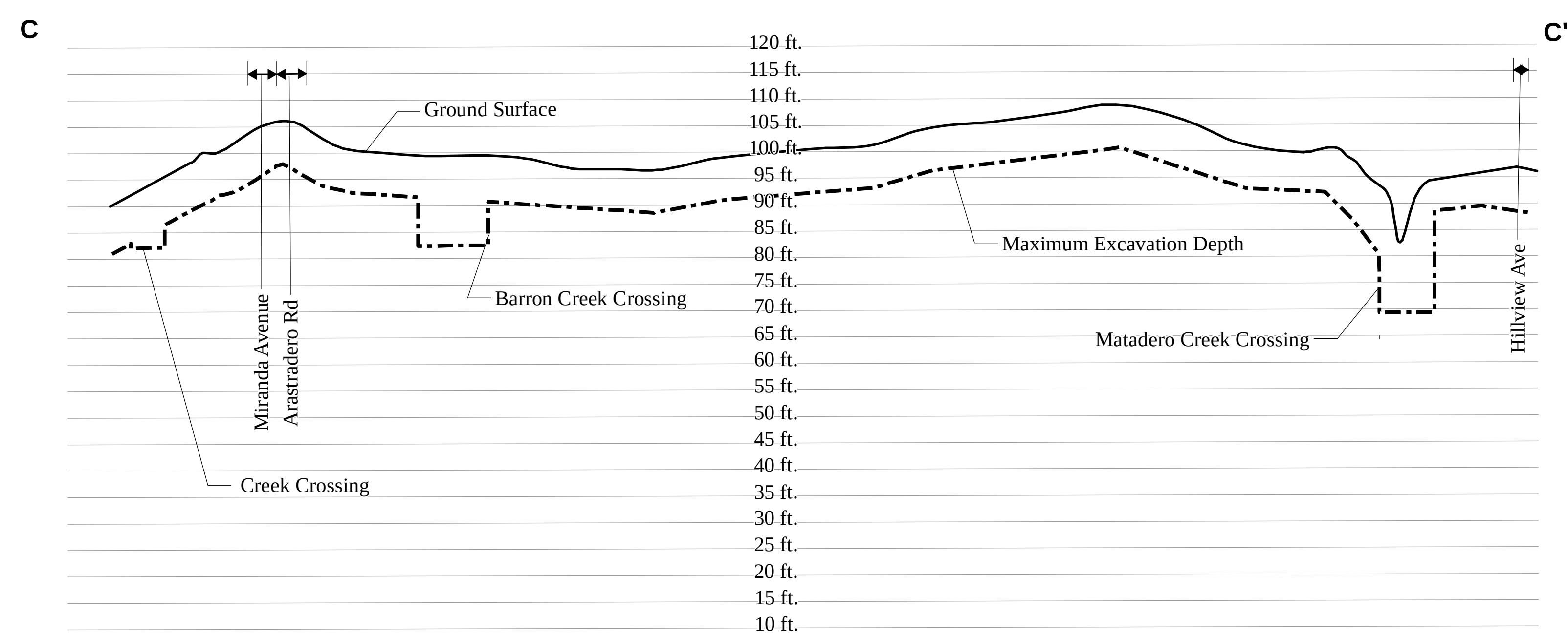


WSA

Archaeological Horizontal and Vertical Area of Potential Effects

Figure 4
Map 2 of 7
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA





Vertical Area of Potential Effects (APE)

- Ground Surface
- Maximum Excavation Depth
- Elevation, Feet (NAD 1988 Datum)

0 750 1,500 Feet

WSA

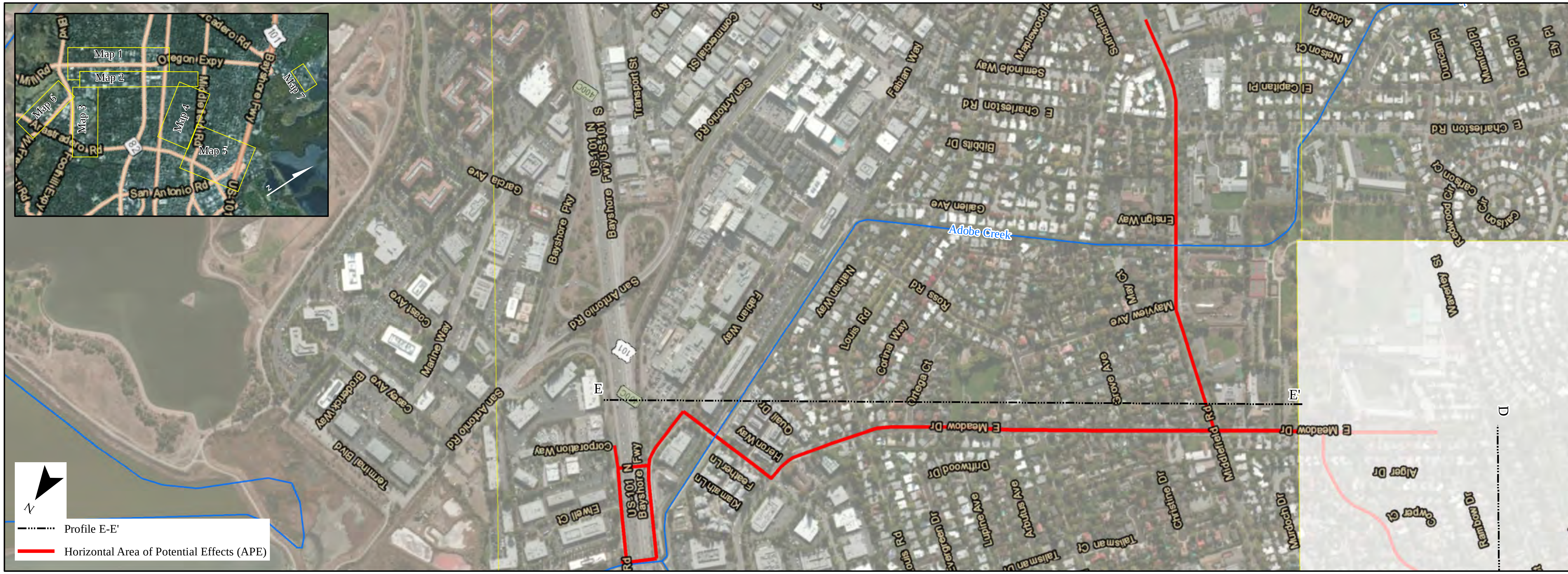
Archaeological Horizontal and Vertical Area of Potential Effects

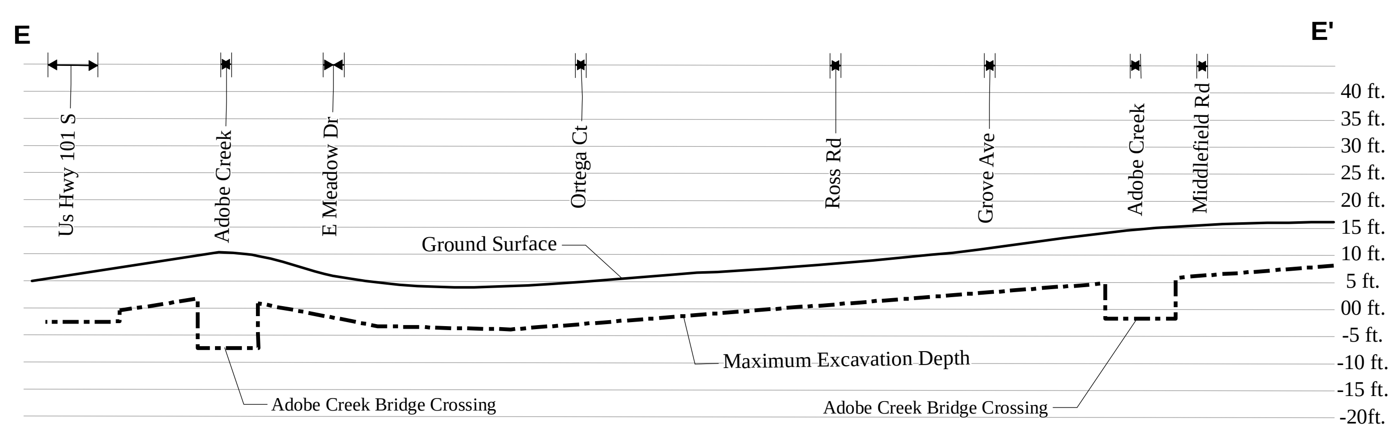
Figure 4
Map 3 of 7
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA

WSA

Archaeological Horizontal and Vertical Area of Potential Effects

Figure 4
Map 4 of 7
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA





Vertical Area of Potential Effects (APE)

Ground Surface

Maximum Excavation Depth

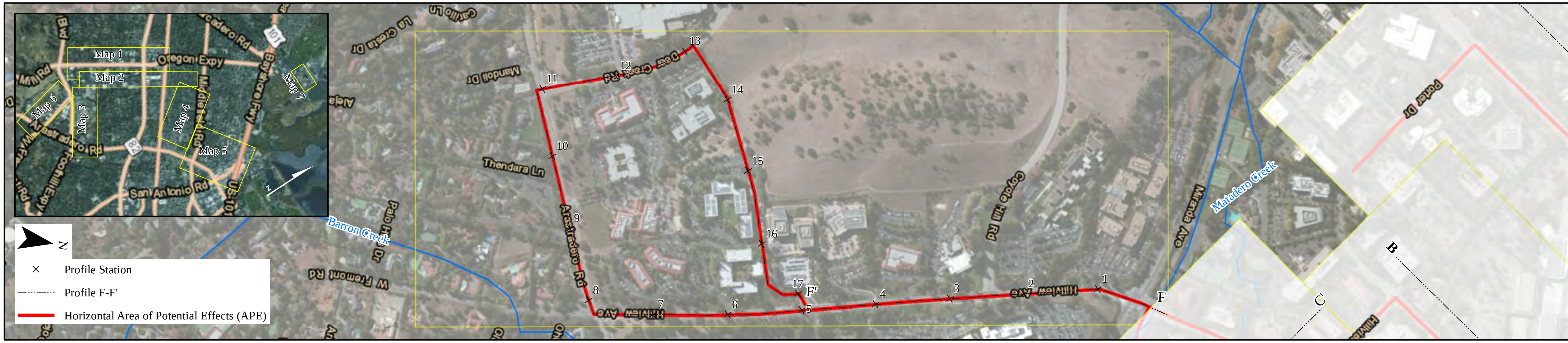
Elevation, Feet (NAD 1988 Datum)

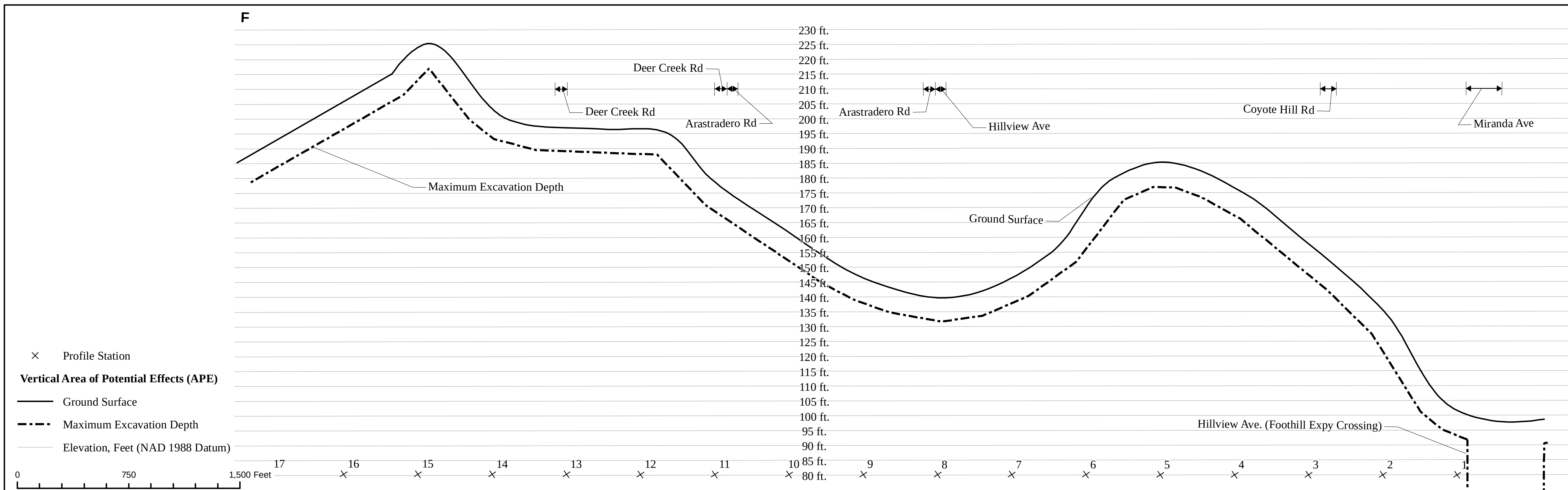
0 750 1,500 Feet

WSA

Archaeological Horizontal and Vertical Area of Potential Effects

Figure 4
Map 5 of 7
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA

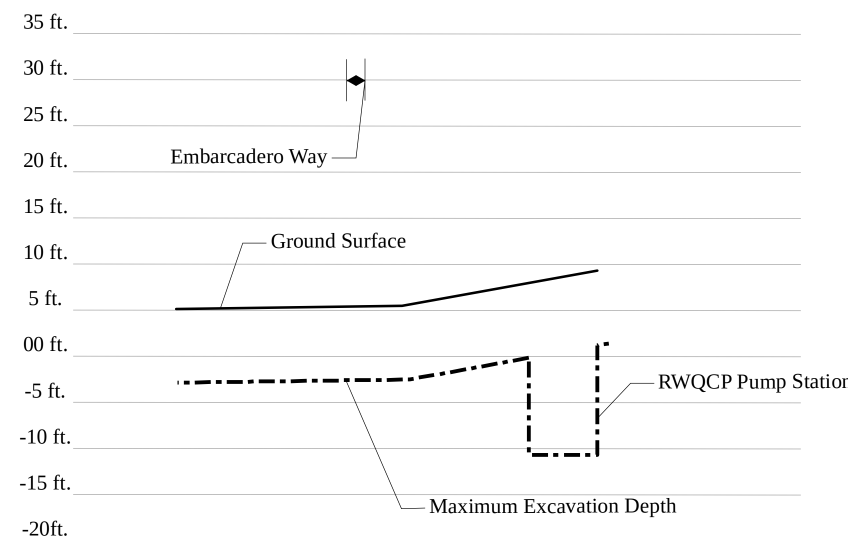




WSA

Archaeological Horizontal and Vertical Area of Potential Effects

Figure 4
Map 6 of 7
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA



Vertical Area of Potential Effects (APE)

Ground Surface

Maximum Excavation Depth

Elevation, Feet (NAD 1988 Datum)

0 400 800 Feet

WSA

Archaeological Horizontal and Vertical Area of Potential Effects

Figure 4
Map 7 of 7
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA

2.2 Archaeological Sensitivity of the Project Area

Archaeological sensitivity modeling is a technique used to predict the potential for finding archaeological sites based on known site locations and assumptions about human behavior (e.g., Dalla Bonna 1994; Ebert and Singer 2004; Kamermans and Wansleeben 1999; Kohler and Parker 1986). The advent of GIS has greatly enhanced the analysis of spatial relationships and increased the power of predictive models of archaeological sensitivity (e.g., Kvamme 1990; Savage 1989; Warren 1990).

Archaeological sensitivity models are primarily inductive, or descriptive, and commonly employ topographic and hydrologic variables such as elevation, slope, aspect, and distance to nearest water. Archaeologists disagree as to the utility of simple versus complex models, the number and nature of variables, and the goal of the models. Most archaeologists prefer a simpler model, which uses three (e.g., Dean 1983:11; Altschul 1990:229-30) to four (e.g., Kvamme 1985; Parker 1985; Carmichael 1990) variables that describe the modern setting of archaeological sites. The present archaeological sensitivity model relies on soil type, slope, and distance to nearest water as the basis for calculating areas of high, medium and low archaeological potential within the project area. Developing the predictive model involved a series of steps, each of which utilized statistical analysis within the ArcGIS 10.2 software package.

The GIS analysis performed in ArcGIS resulted in a predictive surface, or layer of archaeological sensitivity, calculated pixel by pixel combining all three variables. The archaeological sensitivity model depicted in Figure 5 shows the distribution of low, moderate, and high archaeological sensitivity within the project vicinity. The areas of highest sensitivity are in the northern and eastern portions of the project area and are concentrated within well developed alluvial deposits along the major creeks in the area.

The archaeological sensitivity study is based on a soils report prepared for the Project buy David De Vries of Mesa Technical in Berkeley, California, (De Vries 2008). His report is based upon review of the older Santa Clara Area soil survey (Gardner et al. 1958), mapped just before WWII, and more recent geotechnical reports by various authors for specific building sites within the Project APE. Most of what follows is taken from De Vries 2008.

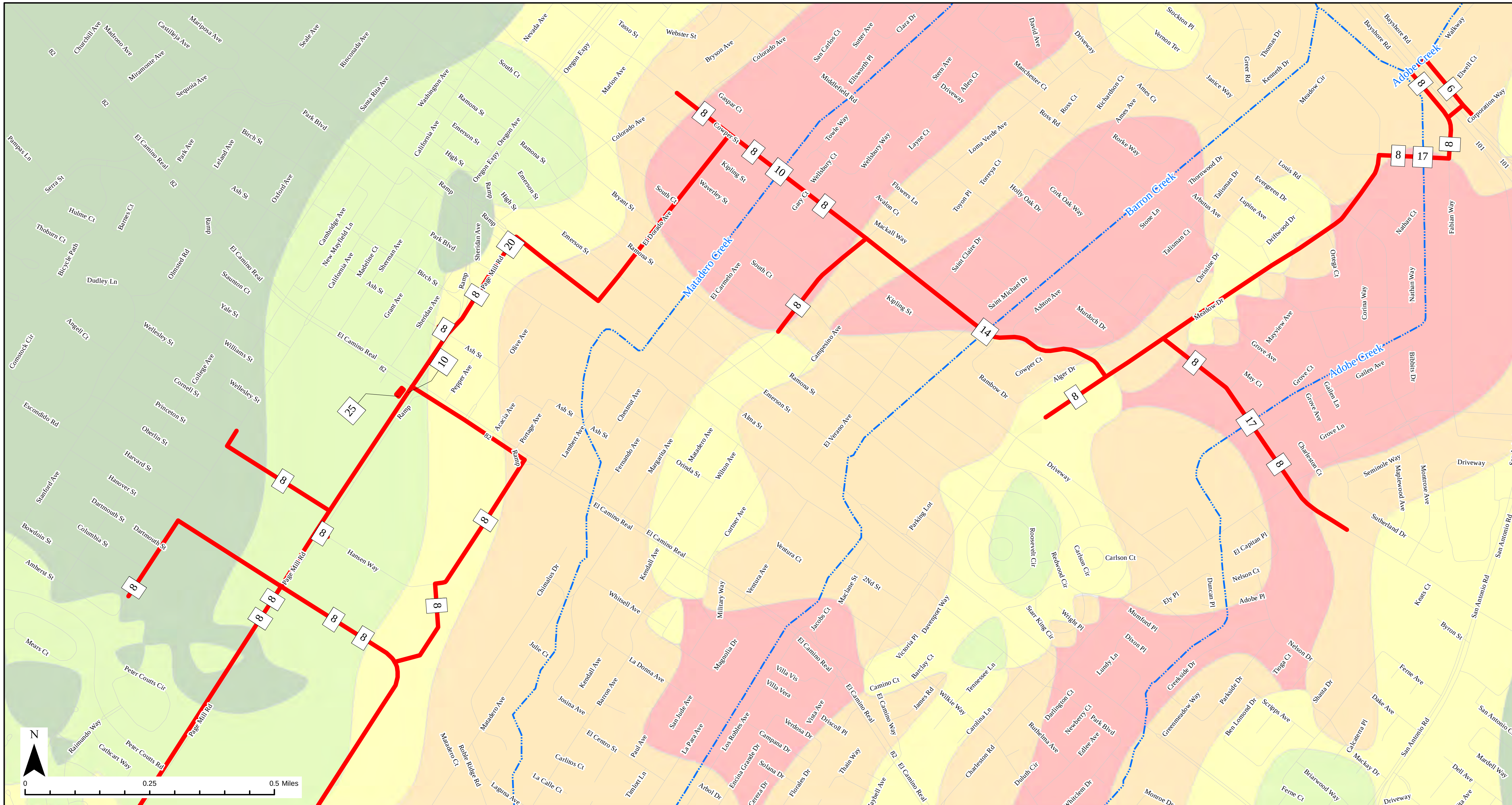
Geographically, the Project APE includes an approximately 2 mile by 4 mile area of southeastern Palo Alto, stretching northeast from the hills just south of Stanford University to the Bayhore Freeway, US-101. Geomorphologically, the Project APE is similar to other urban landscapes ringing the central and south parts of San Francisco Bay, in that rolling foothills give way to broad swaths of older, then younger alluvial fan aprons, cut by recent streams which have eroded the uplands and older fans, then have deposited channel sands and gravel, shifted course, and built terraces, levees, and extensive floodplains along their descent to San Francisco Bay.

<u>Basin Soils</u>

A large part of the APE, 40-50%, has been mapped on low ground near the Bay as one of three types of heavy textured, poorly drained soils, members of the Clear Lake, Sunnyvale, or Alviso series. All are on formerly wet, or seasonally wet grassland that now has been diked, drained, and reclaimed. These soils are less affected by high water tables now, since drainage ditches or tile drains have been installed. Also, pumping for urban use, and formerly for agricultural irrigation, has lowered the local water table.

The Clear Lake soils, 0-1% slopes (Cm), on the upper rim of the basin, are highest in elevation and least affected by salt or lime accumulation. They probably represent former freshwater floodplain deposits. The Clear Lake clay has an A-C horizonation that has developed within deep alluvial deposits. The A-C pattern of Clear Lake soil horizonation, and lack of a B horizon, thus does not reflect frequent episodes of deposition, as on an alluvial fan, but rather the constant top to bottom churning of the soil, making an undifferentiated mass of the top four feet. Blocks and prisms of soil slid against each other with each wetting and drying episode, forming smooth slickenside surfaces and destroying any stratigraphic integrity that subsurface cultural deposits may have once had. The Clear Lake soils are wet for nearly half the year, and thus not good sites for permanent camps, though being adjacent to wetter marshland, they may have been used for temporary hunting or fishing camps during the summer. Their massive structure, extremely hard dry consistence, and very sticky, plastic nature when wet, would have made them unappealing or impossible to dig for storage pits or burials. They are unlikely to have been used for those purposes, with well drained soils of better tilth so close at hand. We would rate the Clear Lake soils as having a low potential to contain buried features associated with sustained, long term occupation.

The Alviso soils, 0-1% slopes (An) occur on the lowest ground nearest the Bay, formerly tidal marsh, and are affected by sodium and other salts throughout their profiles. The Alviso clay occurs on level ground in a lower topographic position than the Clear Lake or Sunnyvale basin soils. The parent material of the Alviso clay is fine textured alluvium, similar to the parent material of the other basin soils in the Project area. However, the source of the Alviso parent material is more likely to have been suspended mud from the Bay than alluvium from the hills above Palo Alto. The Alviso soils do not shrink and swell to the degree that the Clear Lake soils do, so the vertisolic churning of the A horizon is absent. Furthermore, the Alviso clay has a saline water table at 2-3 feet depth, which limits vegetation to salt tolerant grasses and pickleweed, and keeps the entire profile moist or wet at most times. The consistently damp soil conditions and low energy environment of aggradation favor the development of buried A horizons, resulting in A-C-Ab-2C paleosolic profiles. The A-C pattern of Alviso soil horizonation, and lack of a B horizon, reflects frequent episodes of deposition, without sufficient time for eluviation of clay to form a B horizon. The Alviso soils are wet or damp nearly all the time, and thus not good sites for sustained, semi-permanent camps. However, the gentle, low



WSA

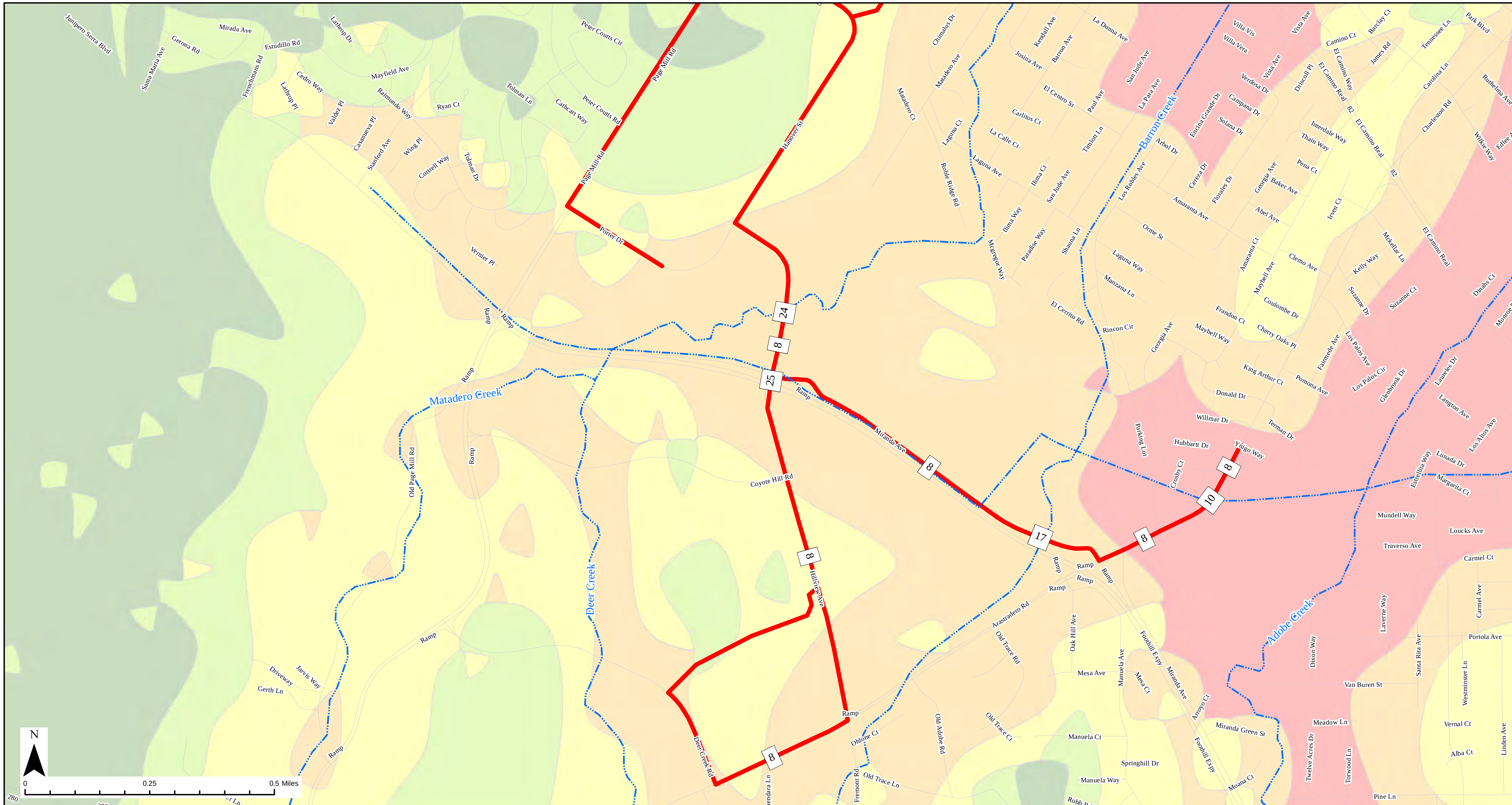
Archaeological Sensitivity Ranks

- High
- High to Moderate
- Moderate
- Moderate to Low
- Low

- Street
- Stream
- 8* Horizontal Area of Potential Effects (APE)
  *Maximum Excavation Depth (in feets)

Archaeological Sensitivity Map

Figure 5
Map 1 of 2
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA



WSA

Archaeological Sensitivity Ranks

- High
- High to Moderate
- Moderate
- Moderate to Low
- Low

- Street
- Stream
- 8* Horizontal Area of Potential Effects (APE)
  *Maximum Excavation Depth (in feets)

Archaeological Sensitivity Map

Figure 5
Map 2 of 2
RMC
Palo Alto Recycled Water Facility Project
Palo Alto, CA

energy environment of sedimentation would be very favorable to the undisturbed burial of whatever artifacts might be present as a result of seasonal use.

The Sunnyvale soils, 0-1% slopes (Sx) are intermediate, having more marly lime than the Clear Lake soils, but not so high sodium levels as the Alviso soils. The Sunnyvale clay is mapped on large areas of level ground in an intermediate topographic position between the Clear Lake soils on the high side, and the Alviso soils on the low side. It is black, calcareous clay. Like the Alviso and Clear Lake soils, the Sunnyvale soil developed from fine textured floodplain alluvium in a low energy depositional environment. However, since the soil is wetter than the Clear Lake, and drier than the Alviso, the Sunnyvale has unique properties: its mixed minerology reduces the seasonal cracking, swelling, churning tendencies of basin rim soils like the Clear Lake, and its drier topographic position than the Alviso makes the Sunnyvale soil relatively rich in lime (CaCO3) but mostly leached free of sodium, the more soluble salt. The intermediate soil wetness regime and heavy texture makes the Sunnyvale a grassland or prairie soil, a mollisol. The high organic matter content near the surface (from the grass roots) and high calcium content throughout tend to flocculate the clay and promote a granular, workable soil tilth, except during summer, for longer periods than on the Clear Lake soils. Gardner reports occasional gravel in some locations, deep in the subsoil or in parent material. This would seem to indicate that the Sunnyvale in places overlays Zamora or Dublin fan deposit soils at depths of only 5-7 feet. Pedologically, the Sunnyvale clay and its underlying sediments have a high potential to contain buried paleosols, reflecting either the gentle depositional environment of the floodplain, or the more energetic environment of the lower alluvial fans. On and within these paleosols, archaeological sites undoubtedly exist, so the archaeological potential is high. However, considering the vast areas mapped to Sunnyvale soil, and the very small percentage of this area to be disturbed within the APE, the chances of actually encountering a site are low.

The Alviso and Sunnyvale soils are mapped on large areas of bayside flood plain, characterized by late Holocene alluvium deposited in a gentle, low energy, aggradational environment. Such a sedimentation regime is ideal for the intact burial of archaeological features, despite the fact that the obdurate soil texture and poor drainage make the presence of such archaeological features unlikely within the greatest part of the land so mapped. However, invisible to us today, either because of historic agricultural land leveling, and subsequent urban usage, or because of being covered with a thin veneer of recent flood sediment, there are bound to be small areas of buried landforms such as former stream levees or low dunes, on land near the present or former Bay shore. These areas have a high archaeological potential to contain shell midden deposits, because of offering dry soil within a fish and game rich marsh, sometimes with permanent fresh water nearby. So it is appropriate to say that most areas of the Alviso and Sunnyvale soils have low potential, except for small areas near former creek channels, and near former dunes. Such areas could be very shallowly buried, and unmapped on soil surveys, as they are covered by a thin layer of fine textured recent sediment that is undistinguishable from the Sunnyvale or Alviso surfaces.

Scattered geotechnical data exist for that part of the APE located on basin soils, showing gravel deposits at depth, usually below 16 feet (Berlogar Geotechnical Consultants 2006; Berlogar, Long & Associates 1981; Jones 1980; and Lowney & Associates 1988) The data are indicative of mid Holocene or earlier fan deposits, from a time when water levels in the Bay were much lower, and the fans originating in the uplands to the southwest extended farther to the northeast. The archaeological potential of these deposits would be lower than for more recent fan deposits because the food-rich Bay would have been at a greater distance, and thus it would have been less likely that the land was occupied on a sustained basis. Conversely, there are probably deeply buried shell middens along former Bay shore, below tidal mudflats, well out from this project's APE, on land now flooded.

Recent Fan and Floodplain Soils

Approximately 30% of the APE surface soil has been mapped as Dublin clay, Dublin clay loam, or Zamora clay loam. These soils developed on recent alluvial fan material, near the distal edges of their fans, from sandstone and shale sediments. The degree of profile development is low. These soils have Bt horizons, but only barely, probably indicating an age not greater than mid-Holocene. Their relatively fine texture indicates a low energy depositional environment, thus favoring the undisturbed burial of any cultural features that happen to be present. Their geographic position adjacent to the Clear Lake basin soils, and the shapes of some map units, is suggestive of interfingering sediment deposits, with non-vertisolic Dublin and Zamora soils developing in one place (favoring preservation of cultural features), and churning, vertisolic Clear Lake soils developing at the surface nearby (favoring destruction of any archaeological record). These radical differences in soil behavior exist because of differing minerology and shrink-swell potential in the parent material. The Dublin soils are associated with small watersheds and intermittent streams, whereas the Zamora soils are associated with the larger watersheds and higher energy streams such as Stevens Creek, San Francisquito Creek, and Permanente Creek.

The Dublin series (Dublin clay, 1-3% slopes [Dh]; 3-6% slopes, [Dg] and Dublin clay loam, 1-3% slopes [Dl]) is mapped on gently sloping ground in an intermediate topographic position between the Clear Lake soils on the low side, and the Milpitas and Ohmer soils on terraces to the southwest. The Dublin is a black, noncalcareous, heavy textured soil of fans and floodplains associated with small watersheds, the rounded grassy foothills of the urban fringe, rather than the mountainous uplands. The surface horizons crack upon drying, and thus would be likely to destroy stratigraphic relationships of artifacts formerly at the ground surface. The Dublin soils are considered to have a high probability of having buried paleosols, because of a high organic matter content and a rapidly aggrading geomorphological position, but the potential for deeply buried sites is low, because of the rare or intermittent water supply in these small watersheds. For areas of the Dublin soils adjacent to Zamora soils, the potential for deeply buried sites would be greater, of moderate probability, because Zamora landforms are more likely to be near a permanent stream.

The Zamora series (Zamora gravelly clay loam, 1-3% slopes [Ze]; Zamora silty clay loam, 1-3% slopes [Zf]; Zamora clay loam, 0-6% slopes [Za]), like the Dublin, is mapped on gently sloping recent fans and floodplains. Zamora soils are old enough to show slight illuviation of clay in the B horizons, but not so old as to pre-date the possibility of human cultural usage. They are probably younger than mid-Holocene in age. The Zamora parent sediments were transported to their fan, floodplain, and low terrace positions by the area's larger streams, draining watersheds in the Santa Cruz Mountains. Indeed, the prevalent fan soils mapped by Gardner are combinations of Zamora (A-Bt-C), Yolo (A-C), and Sorrento (A-Ck) soil types, reflecting typical patterns of fan building, as the runoff wanders over the fan surface, and areas presently covered by gravelly or sandy deposits are then buried by finer material, silty clay loam and clay, as the channel shifts away. Over time, Bt horizonation develops on the less frequently flooded sediments. Zamora soils can present a very complicated three-dimensional volume, a vertical APE that may show several buried surfaces, or none, depending upon the frequency and violence of the fan building storm events. Zamora soils are moderately well drained, and would most of the time have a drier surface than the adjacent (to the northeast) Clear Lake clay. The archaeological sensitivity of the Zamora soils is high, especially near Barron Creek and Matadero Creek, where the Zamora presence on both sides of the waterway indicates both a stable channel and long term stable land surfaces.

Upland soils

Small areas of upland soils are mapped within the APE, in the Vallecitos, Gaviota, and Los Trancos series: Vallecitos clay loam, 20-35% slopes (Va); Gaviota loam, 20-35% slopes (Gk); Los Trancos stony clay, 10-35% slopes (Lg). These are shallow, residual soils developed on bedrock. The Vallecitos soil has an A-Bt-R horizonation, with hard, partially metamorphosed sedimentary rock at about 19" depth. The textural B horizon has developed directly from the weathering of the parent material, rather than from eluviation of clay from A to B horizons. The Gaviota loam has an A-R horizonation, with hard sandstone at 15-25 inch depth. The Los Trancos soil developed from basic igneous rock, and is only 3-10 inch deep. As with the Vallecitos soil, the fine texture results from the chemical weathering of the parent material into montmorillonitic clay minerals, rather than from long term, stable landscape processes such as gradual translocation of clay from A to B horizon. The upland soils are on hillsides, with areas of rock outcrops. Erosion is a constant factor in keeping these soils shallow, and genetically young. The archaeological potential for deeply buried sites is low; artifacts are more likely to be at the surface, perhaps chronologically mixed and concentrated, as the matrix of fine soil material washes downslope, leaving a residuum of relatively heavy cultural materials in place. We have also found on similar soils that bioturbation has thoroughly churned the cultural artifacts, if present, and there are likely to be isolated artifacts now resting directly on bedrock, that were once at the surface.

Terrace soil

Surrounding the upland soils in the southern and western parts of the APE are well-developed stream terrace soils of the Ohmer and Milpitas series. Soils of stream terraces would seem to have a high potential for harboring buried archaeological sites, because recent (first terrace) soils are often flat, dry, easy to dig, and very near to the water of their parent stream. And unlike alluvial fans and floodplains, they do not occupy broad swaths of the landscape, so the high cultural potential is concentrated within a relatively small area. Yet not all terrace soils have a high archaeological potential, for reasons of age, drainage, or the presence of superior locations nearby. The Milpitas and Ohmer soils are moderately old, and both have impaired drainage because of claypan subsoils. The Milpitas soil especially has poor drainage, and is often saturated after winter rains.

The Milpitas soils (Milpitas loam, 3-10% slopes [Mg]) have an easily worked loamy surface horizon overlying, quite abruptly, a clay Bt horizon of more reddish color. This Bt horizon overlies sandy or gravelly alluvium, in some places partially consolidated, that is, becoming cemented with silica or iron in solution. The clay subsoil is a well developed Bt horizon, its sharp upper boundary, thickness, color, and substantially higher clay content (as compared to the A horizon) indicating a long period of landscape stability and soil development. The Ohmer soils (Ohmer clay loam, 3-10% slopes [Oa]; Ohmer clay loam, 10-20% slopes [Oc]) are slightly less pronounced in their degree of development. Ohmer soils are darker in color at the surface, with a slightly less compact Bt subsoil. These soils are probably older than mid-Holocene, but the Milpitas soils appear to be older than the Ohmer soils, perhaps of early Holocene age. Despite their ideal geomorphic position, we would estimate the potential for deeply buried archaeological sites to be low in the Milpitas soil areas, because of their age. Since the Ohmer soils are less well developed, thus younger, we would estimate a higher probability of a Holocene paleosol buried beneath today’s profile, and thus assign a moderate archaeological potential to the Ohmer soils.

Older Fan soils

Large areas of older fan soils lie exposed along the northeast foot of the uplands at the western edge of the Santa Clara Valley, where they have not been buried by recent fan sediments now mapped as Yolo, Zamora, and Dublin soils. Small areas of the Pleasanton and San Ysidro series are mapped within the project APE. Older fan soils, just as the older terrace soils described above, have well developed B horizons resulting from long periods of landscape stability.

The Pleasanton soils (Pleasanton gravelly loam, 1-3% slopes [Po]; Pleasanton loam, 1-3% slopes [Ps]; Pleasanton loam, 3-10% slopes [Pr]) are characterized by a thick A horizon, a loam to clay loam increase in texture from A to the rather deep Bt horizon, a slight reddening of color from A to Bt, and a "clear" boundary along the upper Bt transition, rather than an "abrupt" horizon boundary. These properties indicate moderate soil development, as opposed to strong or extreme development. The Pleasanton soils probably have a younger than mid-Holocene history. Their archaeological potential would be moderate on the west, where they border the Zamora and Dublin soils, but high in the east part of the APE, where they border San Antonio Creek. The San Ysidro soils (San Ysidro loam, 1-2% slopes [Sb]) have a strongly developed profile: a loam A horizon makes an "abrupt" transition to a clay Bt with columnar structure, bleached column tops, and continuous clay films bridging pores and coating peds. The C horizon is strongly calcareous; some of this lime is segregated. On a fan surface, these properties would indicate an older, very stable landscape history, probably early Holocene. On a valley floor, the strong profile development may indicate not only old age, but also a long term regime of winter ponding and long periods of wetness after every rain. The archaeological potential of these soils is low, not only because of their age, but also because of the clayey, very firm, sticky, and very plastic properties of the subsoil, which would make habitation or use difficult and unpleasant for much of the year. Better, drier soils of the Ohmer and Milpitas series are close by, and would be preferentially favored.

Areas of Archaeological Sensitivity

Based on the criteria of soil type, slope, and distance to nearest water present the archaeological sensitivity model for the project has identified areas of high, medium and low archaeological potential within the project area (Refer to Figure 5). Project components are located in five areas of high archaeological sensitivity and two areas of high to moderate archaeological sensitivity. Six of these areas are in the vicinity of the creek crossings and the seventh lies in an area between creeks.

- The Adobe Creek crossing on East Meadow Drive is located in an area of high archaeological sensitivity
- The Adobe Creek crossing along Middlefield Road is located in an area of high archaeological sensitivity
- The Barron Creek crossing along Cowper Street is located in an area of high archaeological sensitivity
- The Matadero Creek crossing along Cowper Street is located in an area of high archaeological sensitivity

- The lateral line along Arastadero Road northeast from the intersection with Miranda Avenue is located in an area of high archaeological sensitivity
- The Matadero Creek crossing along Hillview Avenue is located in an area of high to moderate archaeological sensitivity
- The Barron Creek crossing along Miranda Avenue is located in an area of high to moderate archaeological sensitivity

2.3 Cultural Setting

Prehistoric Archaeological Background

Research into local prehistoric cultures began when Nels C. Nelson of the University of California, Berkeley, conducted the first intensive archaeological surveys of the San Francisco Bay region from 1906 to 1908. Nelson documented hundreds of shellmounds along the shoreline of the San Francisco Bay, when much of the area was still ringed by salt marshes (Nelson 1909:322ff.). He maintained that the intensive use of shellfish – a subsistence strategy reflected in both coastal and bayshore middens – indicated a general economic unity in the region during prehistoric times, and he introduced the idea of a distinctive San Francisco Bay archaeological region (Moratto 1984:227).

In 1911, Nelson supervised excavations at CA-SFR-7 (the Crocker Mound) near Hunter's Point in San Francisco County, a site later dated from 1050 B.C. to A.D. 450. L. L. Loud identified archaeological components from this same period in Santa Clara County in 1911 while excavating at CA-SCL-1 (the Ponce, Mayfield, or Castro Mound site). R. J. Drake recognized them in San Mateo County in 1941–42 at CA-SMA-23 (Mills Estate) in San Bruno (Moratto 1984:233).

The work of Nelson and Loud in the Bay Area provided the impetus for investigation into the prehistory of central California, which began in earnest in the 1920s. Stockton-area amateur archaeologists J. A. Barr and E. J. Dawson excavated a number of sites and made substantial collections in the area from 1893 through the 1930s. On the basis of artifact comparisons, Barr identified what he believed were two distinct cultural traditions. Dawson later refined his work into a series of Early, Middle, and Late sites (Ragir 1972; Schenck and Dawson 1929).

Professional or academic-sponsored archaeological investigations began in the 1930s when J. Lillard and W. Purves of Sacramento Junior College formed a field school, conducting excavations throughout the Sacramento Delta area. By seriating artifacts and mortuary traditions, they identified a three-phase sequence similar to Barr's and Dawson's, including Early, Intermediate, and Recent cultures (Lillard and Purves 1936). This scheme went through several permutations, including Early, Transitional, and Late Periods (Lillard et al. 1939) and Early, Middle, and Late Horizons (Heizer and Fenenga 1939). In 1948 and again in 1954, Richard

Beardsley refined this system and extended it to include the region of San Francisco Bay. The result is referred to as the Central California Taxonomic System (CCTS) (Beardsley 1948, 1954; Moratto 1984). Subsequently the CCTS system of Early, Middle, and Late Horizons was applied widely to site dating and taxonomy throughout central California.

Inevitably, as more data were acquired through continued fieldwork, local exceptions to the CCTS were discovered. Coupled with the accumulation of these exceptions, the development of radiocarbon dating, introduced in the 1950s, and of obsidian hydration in the 1970s, opened up the possibility of dating deposits more accurately. Much of the subsequent archaeological investigation in central California focused on the creation and refinement of local versions of the CCTS.

The difficulties of creating a broadly applicable culture history are fully discussed by Bennyhoff and Fredrickson in Hughes (1994). Given the expanse of central California as well as the complex nature of cultural change over space and time, this single system is limited to providing a general framework for assigning newly found materials to existing culture chronologies. Nonetheless, a modification of the CCTS (Bennyhoff and Hughes 1987; Milliken and Bennyhoff 1993) that presents an Early, Middle, and Late Period with associated transitional periods and subperiod phases remains a useful way to assign dates or cultural periods, or both, to newly discovered features or assemblages. Complementary techniques such as obsidian hydration or radiometric measurements further increase the accuracy of these assignments.

Of some relevance for the current project is a chronological scheme developed by Bennyhoff and Hughes (1987:149). In brief and general form, this scheme includes the following periods and chronology:

- Early Period, ca. 6000–500 B.C.
- Early/Middle Period Transition, ca. 500–200 B.C.
- Middle Period, ca. 200 B.C.–A.D. 700
- Middle/Late Period Transition, ca. A.D. 700–900
- Late Period, ca. A.D. 900–1750

These periods of the CCTS are associated with patterns such as the Windmiller, Berkeley, and Augustine patterns. A pattern is

> [an] adaptive mode(s) extending across one or more regions, characterized by particular technological skills and devices, particular economic modes, including participation in trade networks and practices surrounding wealth, and by particular mortuary and ceremonial practices. (Fredrickson 1973:7–8)

The Windmiller Pattern sites are most often found in the Early Period (ca. 6000–500 B.C.), but they are known to extend into the Middle Period, possibly as late as A.D. 500 in certain areas (Moratto 1984:210). Windmiller Pattern sites are often situated in riverine, marshland, or valley floor settings, as well as atop small knolls above prehistoric seasonal floodplains, locations that provided a wide variety of plant and animal resources. Most Windmiller Pattern sites have burials with remains that are extended ventrally, oriented to the west, and that contain copious amounts of mortuary artifacts. These artifacts often include large projectile points and a variety of fishing gear such as net weights, bone hooks, and spear points. The faunal remains indicate that the inhabitants hunted a range of both large and small mammals. Stone mortars and grindstones for seed and nut processing are common finds. Other artifacts—such as charmstones, ocher, quartz crystals, and *Olivella* shell beads and *Haliotis* shell ornaments—suggest the practice of ceremonialism and trade.

Some scholars have suggested that Windmiller Pattern sites are associated with an influx of people from outside California who introduced subsistence strategies adapted for a riverine-wetlands environment (Moratto 1984:207). Windmiller assemblages have been found to overlap in time with those of the Berkeley Pattern (Moratto 1984).

The Berkeley Pattern has been found from at least 3000 B.C. in the east San Francisco Bay (e.g., Alameda District) (Bennyhoff 1982; Hughes 1994), with the number of sites increasing through A.D. 1 (Moratto 1984:282). The people characterized by the Berkeley Pattern expanded eastward to the Central Valley after about 500 B.C. Berkeley Pattern sites are much more common and well documented, and therefore better understood, than Windmiller Pattern sites. Berkeley sites are scattered in more diverse environmental settings, but riverine settings are prevalent.

Deeply stratified midden deposits that developed over generations of occupation are common to Berkeley Pattern sites. These middens contain numerous milling and grinding stones for food preparation. The typical body position for burials is tightly flexed, with no particular preference for orientation. Associated grave goods are much less frequent than with either the Windmiller or the Augustine pattern. Projectile points in this pattern are larger in earlier times but become progressively smaller and lighter over time, culminating in the introduction of the bow and arrow during the Late Period. Wiberg (1997:10) claims that large obsidian lanceolate projectile points or blades are unique to the Berkeley Pattern. *Olivella* shell beads include Saddle (F) and Saucer (G) types. *Haliotis* pendants and ornaments are occasionally found. Slate pendants, steatite beads, stone tubes, and ear ornaments are unique to Berkeley Pattern sites (Fredrickson 1973:125–126; Moratto 1984:278–279). As with the Windmiller Pattern sites, evidence of warfare or interpersonal violence is present, including cranial trauma, parry fractures, and embedded projectile points.

The Augustine Pattern coincides with the Late Period, ranging from as early as A.D. 700 to about A.D. 1750 and is typified by intensive fishing, hunting, and gathering (especially of acorns), a large population increase, expanded trade and exchange networks, increased ceremonialism, and the practice of cremation in addition to flexed burials. Certain artifacts are also distinctive in this pattern: bone awls used in basketry, small notched and serrated projectile points that are indicative of bow-and-arrow usage, occasional pottery, clay effigies, bone whistles, and stone pipes. *Olivella* bead and *Haliotis* ornaments increase in number of types and frequency of occurrence, sometimes numbering in the hundreds in single burials. Beginning in the latter half of the 18th century, the Augustine Pattern was disrupted by the Spanish explorers and the mission system (Moratto 1984:283).

The establishment of a chronology allows archaeologists to explore other kinds of evidence and research questions that focus on cultural responses to environmental change, settlement and subsistence strategies, trade and exchange routes, population movement, and related topics. Shifting focus from typology to adaptation in the 1970s, Fredrickson identified widespread cultural patterns on the basis of technology (artifacts and inferred skills), economic modes (inferred from processing equipment and food remains), and cultural tradition (e.g., mortuary practices) (Breschini 1983; Fredrickson 1973). Fredrickson identified Paleoindian, Archaic, and Emergent periods inspired by original work by Willey and Phillips (1958). Table 4 summarizes the taxonomic framework developed by Fredrickson (in Hughes 1994).

This scheme places subsistence, organization, and exchange patterns and strategies within a chronological framework. Projectile point types, shell bead and ornament types, and other specific artifact types can be associated with a period by virtue of the dates that may be assigned to them, but this scheme is not defined on the basis of specific types of objects, as is the scheme associated with Bennyhoff, the CCTS.

Table 4. Summary of the taxonomic framework developed by Fredrickson (1973, and in Hughes 1994).

Period and Time Range	Technology, Subsistence	Exchange	Organization
Paleoindian 8000–6000 B.C. Wet and cool; lakeside habitation	Foraging: large projectile points imply hunting with dart and atlatl; groups change habitat to find resources	Ad hoc between individuals	Extended family; little emphasis on wealth
Lower Archaic 6000–3000 B.C. Drying of pluvial lakes, habitations move to rivers, streams	Foraging: milling stones indicate plant food; dart and atlatl imply hunting also important; use of local materials	Ad hoc between individuals	Extended family; little emphasis on wealth
Middle Archaic 3000–500 B.C. Climatic amelioration; local specializations of marine, upland, riverine environments	Foraging: mortars and pestles imply acorn economy; dart and atlatl persist; hunting remains important; tool kits diversify	If changes occur, do not see in archaeological record	Extended family, sedentism begins; growth of population and expansion into diverse niches

Period and Time Range	Technology, Subsistence	Exchange	Organization
Upper Archaic 500 B.C.–A.D. 800 Cooler climate	Foraging, but also some collecting; mortars, pestles; dart and atlatl	More complex: regular exchange between groups; ad hoc continues	Sociopolitical complexity; status distinctions imply wealth; group-oriented religious orgs.; no firm territories
Lower Emergent A.D. 800–1500	Collecting dominates, some foraging; small projectile points imply use of bow and arrow; mortars and pestles persist	Regularized exchanges between groups; more materials in network; ad hoc continues	Status distinctions more pronounced; established territories
Upper Emergent A.D. 1500–1800	Collecting dominates, some foraging; bow and arrow; mortars, pestles; local specialization re: production;	Clam disk beads imply money; local specialization; exchange materials move farther distances; ad hoc continues	

Ethnographic Background

This section provides a brief summary of the ethnography of the San Francisco Bay Area and is intended to provide a general background only. More extensive reviews of Ohlone ethnography are presented in Bocek (1986), Cambra et al. (1996), Kroeber (1925), Levy (1978), Milliken (1995), and Shoup et al. (1995).

The Project area lies within the region occupied by the Ohlone or Costanoan group of Native Americans at the time of historic contact with Europeans (Kroeber 1925:462-473). Although the term Costanoan is derived from the Spanish word costaños, or "coast people," its application as a means of identifying this population is based in linguistics. The Costanoans spoke a language now considered one of the major subdivisions of the Miwok-Costanoan, which belonged to the Utian family within the Penutian language stock (Shipley 1978:82 84). Costanoan designates a family of eight languages.

Costanoan-speaking tribal groups occupied the area from the Pacific Coast to the Diablo Range and from San Francisco to Point Sur. Modern descendants of the Costanoan prefer to be known as Ohlone. The name Ohlone is derived from the Oljon group, which occupied the San Gregorio watershed in San Mateo County (Bocek 1986:8). The two terms (Costanoan and Ohlone) are used interchangeably in much of the ethnographic literature.

On the basis of linguistic evidence, it has been suggested that the ancestors of the Ohlone arrived in the San Francisco Bay area about A.D. 500, having moved south and west from the

Sacramento-San Joaquin Delta. The ancestral Ohlone displaced speakers of a Hokan language and were probably the producers of the artifact assemblages that constitute the Augustine Pattern described below (Levy 1978:486). On the basis of archaeological evidence, Milliken et al. (2007:99) dates the arrival of the Ohlone earlier, to about 2550 B.C. This three thousand year difference in interpretations remains to be resolved.

Although linguistically linked as a family, the eight Costanoan languages comprised a continuum in which neighboring groups could probably understand each other. However, beyond neighborhood boundaries, each group's language was reportedly unrecognizable to the other. Each of the eight language groups was subdivided into smaller village complexes or tribal groups. The groups were independent political entities, each occupying specific territories defined by physiographic features. Each group controlled access to the natural resources of their territories, which also included one or more permanent villages and numerous smaller campsites used as needed during a seasonal round of resource exploitation.

According to Milliken (1995), the tribal group that occupied the northern San Francisco Peninsula at the time of historic contact was known as the Yelamu. In March 1776, the Anza party entered Yelamu territory. At that time approximately 160 Yelamu people inhabited the area (Milliken 1995:53). Milliken (1995:260) states that the villages of Chutchui and Sitlintac near Mission Creek were likely used by one band of Yelamu people at different times of the year. Similarly, the villages of Amuctac and Tubsinte in the Visitation Valley area of San Francisco are also thought to have been inhabited seasonally by another Yelamu band. A third small band is thought to have resided in the village of Petlenuc, possibly located near the Presidio.

The vestiges of many village sites within the San Francisco Bay Area have been found in numerous locations around the Bay shoreline in the form of shell mounds—large accumulations of shell, ash, artifacts, and occasionally human remains. With the influx of European settlers in the mid-19th century, most of these sites were destroyed or buried (Alvarez 1992:4-22).

Extended families lived in domed structures thatched with tule, grass, wild alfalfa, or ferns (Levy 1978:492). Semisubterranean sweathouses were built into pits excavated in stream banks and covered with a structure against the bank. The tule raft, propelled by double-bladed paddles, was used to navigate across San Francisco Bay (Kroeber 1925:468).

Mussels were an important staple in the Ohlone diet, as were acorns of the coast live oak, valley oak, tanbark oak and California black oak. Seeds and berries, roots and grasses, and the meat of deer, elk, grizzly, rabbit, and squirrel formed the Ohlone diet. Careful management of the land through controlled burning served to ensure a plentiful, reliable source of all these foods (Levy 1978:491).

In the more recent prehistoric times through European contact and the early historic period, the Ohlone usually cremated a corpse immediately upon death, but if there were no relatives to gather wood for the funeral pyre, interment occurred. Mortuary goods comprised most of the personal belongings of the deceased (Levy 1978:490).

The arrival of the Spanish in 1775 led to a rapid and major reduction in native California populations. Diseases, declining birth rates, and the effects of the mission system served to disrupt aboriginal life ways (which are currently experiencing resurgence among Ohlone descendants). Brought into the missions (the Yelamu inhabitants joined Mission San Francisco from 1777 to 1787 [Milliken, 1995:260]), the surviving Ohlone, along with the Esselen, Yokuts, and Miwok, were transformed from freely moving hunters and gatherers, into agricultural laborers tethered to the mission locale (Levy, 1978; Shoup et al. 1995). With Mexican independence in 1821 and the subsequent abandonment of the mission system, numerous ranchos were established. Many former mission Indians disbursed, and those who remained were then forced by necessity to work on the ranchos.

In the 1990s, some Ohlone groups (e.g., the Muwekma, Amah, and Esselen further south) submitted petitions for federal recognition (Esselen Nation 2007; Muwekma Ohlone Tribe 2007). Many Ohlone are active in preserving and reviving elements of their traditional culture and actively consult on archaeological investigations.

Historical Background

Spanish Exploration and Colonization

The 1769 expedition led by Captain Gaspar de Portolá initiated contact between Spanish explorers and the native people of the Bay region. The Portolá party set off from San Diego and from Monterey onward followed the coast route north, spending late October and early November on the San Francisco Peninsula. After having traveled north up the Peninsula along the coast, where they were greeted warmly by a succession of native villages (Milliken 1995:31-34), the party crossed the Coast Range ridge and began their journey south along the eastern portion of the Peninsula. The party camped on San Francisquito Creek on November 10. Father Juan Crespí, who recorded the details of the expedition, wrote:

At once upon our reaching here, several very well-behaved heathens, most of them well-bearded, came to the camp, giving us to understand that they were from three different villages, and I do not doubt there must be many of these, from the many smokes seen in different directions (Crespí in Stanger and Brown 1969:105 as cited in Shoup et al. 1995:22).

After a mission and settlement had been established at Monterey, parties began exploring north from a new base of operations. The first to return to the Bay Area in 1770 was Pedro Fages and his party, who chose the inland route instead of the coastal route to the north. Fages and his men explored the eastern shore of San Francisco Bay, passing through the Fremont Plain and eventually reaching the location of modern-day north Oakland. Just south of Alameda Creek, in Fages' only mention of native people in his diary of the exploration, the party encountered a group of local native people.

Up close to the lake we saw many friendly good-humored heathens, to whom we made a present of some strings of beads, and they responded with feathers and geese stuffed with grass, which they avail themselves of to take countless numbers of these birds (Fages [1770] 1939:119 as cited in Milliken 1995:36).

In 1772, a second Fages expedition traveled from Monterey passing through the Santa Clara Valley (Levy 1978:398). After passing northward through the region in March, they explored the inland Diablo Valley as far north as the Carquinez Strait and returned south through the Santa Clara Valley in early April.

Fernando Javier Rivera y Moncada and Father Francisco Palou next explored the region in the fall of 1774 (Beck and Haase 1988:17). They, too, followed the inland route and instead of exploring the east side of the Bay, continued north up the San Francisco Peninsula in search of suitable sites for future missions and military installations. The party distributed gifts to native groups along the length of their route.

The final sites for a military base and the first of the Bay Area missions were chosen during the Anza expedition of 1776. Anza and his men traveled up the Peninsula, where a wounded Indian they encountered in modern-day Belmont made them understand that local tribes were in the midst of a conflict. The party explored the entire area that would become San Francisco and continued on to explore portions of the East Bay. At Alameda Creek they came upon thirty Indian men "speaking a language unlike any they had yet heard" (Milliken 1995:54).

The first mission in the San Francisco Bay Area was established in San Francisco with the completion of Mission San Francisco de Asis (Mission Dolores) in 1776. Mission Santa Clara de Asis, located forty miles south of San Francisco, was established just a year later. Mission San Jose, located in modern Fremont, would not be established for another twenty years. Mission lands were used primarily for the cultivation of wheat, corn, peas, beans, hemp, flax, and linseed, and for grazing cattle, horses, sheep, pigs, goats, and mules. In addition, mission lands were used for growing garden vegetables and orchard trees such as peaches, apricots, apples, pears, and figs.

The missions relied on the Native American population both as their source of Christian converts and their primary source of labor. Though some Indians gave up their traditional way of life by choice, many were coerced, manipulated, and forced into the missions. Soldiers stationed at the Presidio were called upon to both punish those Indian people the priests could not control through more diplomatic means, as well as to retrieve people who attempted to return to their native villages. By the mid 1790s, traditional Costanoan lifeways had been significantly disrupted, and diseases introduced by the early expeditions and missionaries, and the contagions associated with the forced communal life at the missions, resulted in the death of a large number of local peoples. Cook (1943) estimates that by 1832, the Costanoan population had been reduced from a high of over 10,000 in 1770 to less than 2,000.

Mexican Rule and Secularization of the Mission System

Following Mexican independence from Spain in 1821, control of Spain's North American colonial outposts was ceded to the Republic of Mexico. Alta California became a province of the new republic and under Mexican rule Californians could now trade with foreigners and, further, foreigners could own property once they had been naturalized and converted to Catholicism. These new regulations made California more attractive to permanent settlers and, not surprisingly, the numbers of Mexican and non-Mexican born immigrants continued to increase during this period.

Despite this, life remained difficult for Indian people within the mission system. Locally, tensions mounted in the summer of 1829 when Indians of the San Jose and Santa Clara missions rebelled under the leadership of an Indian chieftain, Estanislao, and his companion, Cipriano (Shoup et al 1995:83). The confrontations that took place that summer resulted in casualties for both the Indian rebels and the soldiers serving the mission (Shoup et al. 1995:86). The fact that Indian people who had maintained long-term relationships with local missions were motivated to rebel against them reflected poorly on the institution's ultimate success. Difficulties like these on the local level, as well as the larger issues of administering such a widespread institution, and the desire of the Mexican government to remove the missions' vast land holdings from the control of Franciscan priests, resulted in the secularization of the mission system.

The process of secularization began in California in 1834. Very few Indian people received land as a result of secularization. In the end, former mission lands were parceled out in large land grants, and just as they had done in the missions, Native Americans served as a source of labor for the new landowners. Fifty-eight percent of land grants were made to Mexican citizens, while forty-two percent were made to non-Mexicans who had become naturalized and baptized, gaining access to property in the process (Beck and Haase 1988:24). Prior to secularization, 51 grants had been made in Alta California. "Of the 813 grants ultimately claimed, 453 were filed between 1841 and 1846, 277 from 1844 to 1846, and 87 in the last few months before United States occupation" (Beck and Haase 1988:24).

Throughout the state this meant that the agricultural economy that was once limited to the missions and pueblos quickly encompassed a growing number of cattle ranches run by men interested primarily in the hide and tallow trade. The current project area was situated entirely within the 8,418-acre area of Rancho Rincon de San Francisquito (Beck and Haase 1988:30). In 1841, California Governor Alvarado granted the rancho to Jose Pena, who had been a resident of the area since 1824 (Kyle 1990:406-407).

The Mexican-American War and the Gold Rush Lead to Statehood

As overland migration of American settlers from the east into Alta California became more common in the 1840s, relations between the United States and Mexico became strained, with Mexico fearing American encroachment into their territories. The political situation continued to deteriorate and twice Mexico rejected an American offer to purchase California. In 1836, a revolution in Texas drove out the Mexican government and created an independent republic. This republic was annexed to the United States in 1845, causing a rift in the diplomatic relations of the two nations. The following year Mexico and the United States were at war. American attempts to seize control of California quickly ensued, and within two months, California was conquered by the United States. Skirmishes between the two sides continued until California was officially annexed to the United States in 1848 (Kyle 1990:xiii-xiv).

Shortly after the signing of the Treaty of Guadalupe Hidalgo, the discovery of gold in the Sierra Nevada ignited a major population increase in the northern half of California as immigrants poured into the territory seeking gold or the opportunities inherent in producing goods or services for miners. Prior to the Gold Rush, San Francisco was a small settlement with an approximate population of 800 inhabitants. With the discovery of gold and the sudden influx of thousands of optimistic gold seekers, a city of canvas and wood sprang up as men and goods streamed into the once isolated outpost.

California statehood and the end of Mexican rule ushered in yet another body of laws that governed life in this rapidly changing landscape. Of particular importance to both the people who had established themselves in California during the Mexican era and to those recent immigrants who hoped to settle in California after the gold rush, were the laws governing property ownership. Although Mexican citizens had been assured of their property rights after annexation, the frenzy of the gold rush made northern California's vast rancho lands irresistible to new arrivals, who often squatted on property that they did not own. In 1851 the U.S. government established a land commission to bring order to the increasingly chaotic situation. The three-member commission was assigned the formidable task of authenticating land titles granted by the Mexican government, placing the burden of proof on the property owners themselves. Long-time residents spent much of the next two decades trying to gain clear title to their land, often gaining title only to have to use the land itself to pay the legal bills that had accumulated during the process.

The Final Decades of the 19th Century

Increased settlement after statehood and the division of many of the large ranchos led to a shift from the ranching economy favored by Spanish and Mexican landholders to an economy based at first on cattle and grain agriculure, such as wheat, then increasingly on orchard and specialty vegetable agriculture. Irrigation became a vital component in the region's productivity (Beck and Haase 1988:93-97). Crops such as grapes, peaches, walnuts, and vegetables proved to be particularly suited to the region, and served as a catalyst for an industry built around providing goods and services to farmers.

At the time that Thompson & West mapped Santa Clara County in 1876, the project area extended from the western portion of the marshland acreage owned by Henry Tiffney, 3.5 mi. to the southwest. This encompassed much of the original Rancho Rincon De San Francisquito purchased by Jeremiah Clark in 1859.

Although today the project area is situated near a major transportation corridor, 19th century residents were somewhat isolated from early population centers such as San Francisco due to the region's topography as well as the primitive state of early transportation. Prior to the establishment of railroads, residents relied on ferries to cross the bay and stages and horse cars to navigate the often-difficult roadways.

These early travel corridors were firmly established when railroad lines were constructed throughout the region. Not only were the transcontinental lines established by the Central Pacific and later the Western Pacific important, but the interconnected network of local lines was significant as well. The location of stations along these lines largely determined the points of development that would soon form the downtown cores of the Bay Area's early cities and towns. Similarly, the lines formalized the corridors that would become home to the area's industries that were largely dependent on rail transportation. Future infrastructure, such as highways and public transportation, continued to follow the routes solidified by the railroads.

Overland travelers relied on the well-worn path of El Camino Real until 1864, when the San Francisco-San Jose Railroad Company train established service between San Francisco and San Jose. The rail line ran parallel to El Camino Real and encouraged development east of El Camino near the new train depots (Hynding 1984:64). The Southern Pacific, and in turn, the Central Pacific quickly absorbed the SF-SJ line. It would remain the only rail line on the Peninsula throughout the 19th century (Hynding 1984:64). Near the project area, the Mayfield farm and then the Mayfield railroad depot encouraged early commerce and residential development.

In 1852 a lawyer by the name of Leland Stanford moved from New York to Sacramento. He prospered as a miner, a merchant, and eventually as the President and co-founder of the Central Pacific Railroad, which allowed him to gain political office as Governor. Following his tenure as governor, he concentrated his efforts in successfully making the Central Pacific first transcontinental railroad. This company was later merged with Southern Pacific Railroad. In 1870, Stanford purchased the Rancho San Francisquito. On this land he established a farm dedicated to breeding pedigree racehorses, which he named Palo Alto. In 1884, Stanford's only son died at the age of sixteen. As a memorial to him, Stanford established a university, which was opened for classes in 1891.

The oldest parts of the modern city of Palo Alto were at one time known as Mayfield and College Terrace. Mayfield was established as a town in 1867, although the first schoolhouse there dates to 1855. The town is named after one of the early farms owned by Sarah Wallis, who was the first president of the California Suffrage Association. Subsequent to its founding, Mayfield earned a reputation for the thirteen unruly saloons in town. Stanford disapproved of alcohol and used his influence to modify that reputation. He convinced an associate, T. Hopkins, to purchase 740 acres of land located southeast of Menlo Park, along El Camino Real, which would became known as the town of University Park, and would prohibit the sale of alcohol. University Park soon became known as Palo Alto, and was incorporated in 1894. By 1889, the area between Stanford University and Mayfield was settled. Originally it was called University Terrace but later was subsumed into the growing City of Palo Alto. In 1925 Mayfield was annexed by Palo Alto. The prohibition of alcohol that was started in University Park was continued in Palo Alto until after World War II (Hoover et al. as cited in Kyle 1990: 419-420).

In the 20th century, Palo Alto benefited from technological growth in Silicon Valley. Currently, the city continues to be an economic center for the technology industry. Xerox, Amazon.com, Lockheed Martin, and Hewlett-Packard are major technology firms that maintain offices in Stanford Research Park.

20th Century Expansion

In the early decades of the 20th century, the waterfront communities of the Peninsula became increasingly connected to both San Francisco and the East Bay. El Camino became the first paved highway in the vicinity of the project area, and in the 1930s, the stretch of the newly constructed Bayshore Highway between Redwood City and the Santa Clara Valley was completed (Hynding 1984:258). By 1930, the Dumbarton Bridge (between Ravenswood Point and Dumbarton Point) as well as the San Mateo Bridge linked communities on both sides of the southern portion of San Francisco Bay.

An increasing population required improvements in local infrastructure. When the newly incorporated City of Palo Alto began construction of its first sewage system in 1898, it had been designed to serve approximately 3,000 people. The system discharged into Mayfield Slough, an area that, by the 1920s, was being planned for recreational development. In addition, the presence of a yacht harbor in the vicinity of the sewage outflow, damage to the Baylands park area, tide related overflows, and population growth necessitated a new method of sewage disposal.

The first wastewater treatment facility in Palo Alto began operating in 1934. The original site is still used for the current wastewater treatment facility (the RWQCP in the project area), although it has been substantially renovated over time. The 1934 facility served the 20,500 people of the Palo Alto area as well as a local cannery, processing up to three million gallons of wastewater per day.

While there had been a flood of immigrants into California during the Great Depression, the influx during World War II was substantially greater. The defense industry expanded and cities surrounding the Bay developed rapidly (Kyle 1990: xvi). New shipyards came into existence, the number of factories in use increased by a third, and the population of industrial workers more than doubled (Cole 1988:129). The output of Bay Area shipbuilding facilities - 1,400 vessels during a war that lasted 1,365 days - remains staggering.

California also became an important location for installations of all branches of the United States military during the war. Largely because a portion of the war was fought in the Pacific theater, and the attack on Pearl Harbor made California a strategic location, the Army, Air Force, Navy, and Marines utilized the human and natural resources of the Bay Area for national defense (Beck and Haase 1988:86-88). As well as the industrial facilities along the bayshore, the Alameda Naval Air Station, the Oakland Army Base, Moffett Field, and local Army training camps drew civilian and military families to the communities surrounding the project area.

In addition to heavy industries, such as shipbuilding, high-tech industries such as electronics also expanded rapidly during this period. After the war, these firms began to contribute to the emerging field of communications (Hynding 1984:270). In addition to drawing manpower, the facilities established during the war effort spurred industrial and high-tech research that laid the foundation for today’s economy that is increasingly reliant on the innovation of highly skilled workers.

After World War II, the wastewater treatment facility, part of the project area, was upgraded to process five million gallons of wastewater, and again in 1957 to treat ten million gallons per day. In 1964, a new outflow was built to prevent discharge in the ecologically damaged Yacht Harbor, which had by this time ceased operations. No buildings remain from the 1934 treatment facility.

The facility was expanded in 1969-1972 on the existing site to become a new regional wastewater treatment facility (the RWQCP) serving the communities of Palo Alto, Los Altos, and Mountain View. This secondary treatment facility greatly improved wastewater disposal and reduced pollution in the area. In 1975, and then again in 1978, the facility was upgraded to an advanced tertiary treatment facility. In 1987, the capacity of the plant was expanded again. No pre-1950 original buildings remain at the plant.

3.0 Results of the Records Search

On October 23, 2014, WSA conducted a records search for the Project at the Northwest Information Center at Sonoma State University (NWIC) (File No. 14-0533). The records search included a review of cultural resource and excavation reports and recorded cultural resources within a 1/4-mile radius of the Project APE. The records search also included a review of the Office of Historic Preservation's "Directory of Historic Property Data File for Santa Clara County" and "Archaeological Determinations of Eligibility" for Santa Clara County.

A total of 91 cultural resources studies have been conducted within 1/4 mile of the project APE. Twenty-two (22) studies include or cross some portion of the project components (Table 5).The remaining 69 studies do not include project components but have been conducted within ¼-mile of the project APE (Table 6).

Table 5. Cultural resource studies within the project APE

Survey #	Date	Author	Title
S-005023	1982	Cartier, Robert	Cultural Resources Evaluation for a Parcel for land at 3860 Middlefield Road in the City of Palo Alto, County of Santa Clara
S-009442	1987	Cartier, Robert	Cultural Resource Evaluation of the Matadero Creek Flood Control Project in the City of Palo Alto, County of Santa Clara
S-017993	1995	Hatoff, Brian, Barb Voss, Sharon Waechter, Stephen Wee, and Vance Bente	Cultural Resources Inventory Report for the Proposed Mojave Northward Expansion Project

Survey #	Date	Author	Title
S-022605	1999	Cartier, Robert	Cultural Resource Evaluation of the Sprint PCS Mitchell Park Project at 3600 Middlefield Road in the City of Palo Alto, County of Santa Clara
S-022978	2000	Avina, Mike	Final Cultural Resources Inventory Report for Williams Communications, INC. Fiber Optic Cable System Installation Project, San Francisco to Santa Clara, San Francisco, San Mateo, and Santa Clara Counties, Addendum 1
S-025174	2002	Holson, John, Cordelia Sutch, and Stephanie Pau	Cultural Resources Report for San Bruno to Mountain View Internodal Level 3 Fiber Optics Project in San Mateo and Santa Clara Counties, California
S-027709	2003	Losee, Carolyn	Cultural Resources Analysis for Cingular BA-351-02 Mayfield Station #2 Site (letter report)
S-027908	2003	Environmental Science Associates	Palo Alto Regional Water Quality Control Plant Reuse Pipeline, Cultural Resources Inventory Report
S-029657	2002	Nelson, Wendy, Tammara Norton, Larry Chiea, and Reinhard Pribish	Archaeological Inventory for the Caltrain Electrification Program Alternative in San Francisco, San Mateo, and Santa Clara Counties, California
S-033697	2007	Martorana, Dean	Palo Alto Regional Water Quality Control Plant Reuse Pipeline, Santa Clara County, California: Cultural Resources Inventory
S-022704	2000	Ballard, Hannah	Cultural Resources Survey of the Point to Point Web TV Service Connection, Santa Clara County (letter report)
S-018367	1995	Mark Hylkema, Mara Melandry, and Tom McDonnell	Historic Property Survey Report and Finding of No Effect for the Proposed Ramp Metering and HOV Ramp Project, 4-SCL-101 PM 40.0/52.5, EA 132451

Survey #	Date	Author	Title
S-029573	2000	Jonathan Goodrich	Final Report, Archaeological Survey and Record Search for the Six Fluor Global Fiber Optic Segments, Mountain View, Palo Alto, and San Mateo County, California.
S-034074	2007	Eric Strother, Aimee Arrigoni, Drew Bailey, James Allan, and William Self	Cultural Resource Assessment, Palo Alto Regional Water Quality Control Plant, UV Disinfection Project, Palo Alto, Santa Clara County, California
S-035123	2008	Brian F. Byrd and Michael Darcangelo	Archaeological Survey Report for the US 101 Auxiliary Lanes (Route 85 to Embarcadero Road) Project, Santa Clara County, California, 04-SCL-101 PM 48.97/52.17 EA 04-4A3300
S-037075	2008	Adrian Whitaker	Historic Resources Compliance Report for the U.S. 101 Auxiliary Lanes (Route 85 to Embarcadero Road) Project, Santa Clara County, California, 04-SCL-101 PM 52.17-48.97 EA 04-4A330
S-039266	2012	Jennifer Thomas and Jack Meyer	Cultural Resources Study for the Line 101 South ILI Upgrade Project, Santa Clara County, California
S-039469	2012	Neal Kaptain	Historical Resources Compliance Report for the San Mateo County SMART Corridors Project, Segment III, Redwood City, Atherton, Menlo Park, East Palo Alto, and Palo Alto, San Mateo County & Santa Clara County, California; EA #4A9201; EFIS #0400001169, Caltr
S-043191	2013	Kathleen Kubal and Jay Rehor	Historic Property Survey Report, State Route 85 Express Lanes Project, Santa Clara County, CA, US 101 PM 23.1-28.6, SR 85 PM 0.0-24.1, US 101 PM 47.9-52.0;
S-043191a	2013	Kathleen Kubal	Archaeological Survey Report; Environmentally Sensitve Area Action
S-043191b	2013	Jay Rehor and Kathleen Kubal	Extended Phase I Study, State Route 85 Express Lanes Project, Santa Clara County, California

Survey #	Date	Author	Title
S-044044	2014	Heidi Koenig	Historic Property Survey Report Highway 101 Overcrossing Project Palo Alto, Santa Clara County, CA County Post Mile SCL 50.684

Table 6. Cultural resource studies within ¼-mile of the project area

Survey #	Date	Author	Title
S-004883	1977	Santa Clara County Transportation Agency	Historic Property Survey Report, Oregon-Page Mill Expressway Intersection Improvements at El Camino Real, Palo Alto, CA
S-008420	1981a	Cartier, Robert	Cultural Resources Evaluation of the Peter Coutts Hill project, Stanford University, County of Santa Clara
S-011396	1989	BioSystems Analysis, Inc	Technical Report of Cultural Resources Studies for the Proposed WTG-WEST, Inc. Los Angeles to San Francisco and Sacramento, California, Fiber Optic Cable Project
S-025159	2002	Nadolski, John, and Michelle St. Clair	Archaeological Investigations for the 2950 West Bayshore Road, Wireless Communications Site, CA 2287H
S-029698	2005	Thal, Erika	Equipment Shelter, PG&E City of Palo Alto/ SF-05252A, 1080 Colorado Avenue, Palo Alto, CA.
S-004201	1997	Anonymous	Archaeological Reconnaissance of the Proposed Palo Alto Yacht Harbor Expansion
S-004279	1976	Riley, Lynn	Archaeological Reconnaissance, Proposed Site of Sanitary Land Fill, Santa Clara County, California
S-006051	1983	Clark, Mathew	Archaeological Reconnaissance and Records Search for the Proposed Bryan Canyon/Kaiser Permanente Solid Waste Landfill Access and Transfer Stations

Survey #	Date	Author	Title
S-008589	1981	Cartier, Robert	Cultural Resource Evaluation of the Terman School Low-cost Housing Project near Arastradero and Pomona Avenue in the City of Palo Alto, County of Santa Clara
S-008728	1949	Caldwell, Warren Wendell	The Archaeology of the Stanford-Palo Alto Region
S-014246	1992	Archaeological Resource Management	Cultural Resource Evaluation of the Veterans Administration Medical Center Project in the City of Palo Alto, County of Santa Clara
S-014974	1992	Hammett, Julia	Archaeological Concerns Related to Lockheed's Toxic Substances Control Program (letter report)
S-014975	1992	Bennett, J.M.	Stanford Segment of Line 109/132; Cultural Resources Testing of Site CA-SCL-628 (letter report)
S-016137	1994a	Holman, Miley P.	Archaeological Field Inspection of the Page Mill Road and Foothill Road Expressway Improvement Project, Palo Alto, Santa Clara County, California
S-017518	1975	Jackson, Thomas L.	An Archaeological Reconnaissance of the Junipero Serra Boulevard Study (letter report)
S-018047	1994b	Holman, Miley P.	Archaeological Field Inspection of the Palo Alto Golf Course, Palo Alto, Santa Clara County, California
S-020483	1998a	Price, Barry A.	Cultural Resources Assessment, Pacific Bell Mobile Services Facility SF-530-03,Palo Alto, Santa Clara County, California (letter report)
S-020910	1998	Psota, Sunshine	Review of Historic Resources for Site SF-142-02, 711 Colorado Avenue, Palo Alto, Santa Clara County, CA (50001 84/98) (letter report)

Survey #	Date	Author	Title
S-023888	2001	Losee, Carolyn	Record Search Results for Sprint Spectrum's Personal Communication Series (PCS) Wireless "Long's Drugs" Site (Ref # SF33XC572F) (letter report)
S-028669	2004	Holman, Miley P.	Archaeological File Study of the 901 San Antonio Road Project Area, Palo Alto, Santa Clara County, California
S-029231	2000	Billat, Lorna	Nextel Communications Wireless Telecommunications Service Facility-Santa Clara County, Nextel Site No. (CA-0171A) / Page Mill Road (letter report)
S-029233	n.d.	Billat, Lorna	Nextel Communications Wireless Telecommunications Service Facility-Santa Clara County, Nextel Site No. (CA-0871A)/ Oregon Expressway (letter report)
S-030233	2004a	Losee, Carolyn	Cultural Resources Analysis for Cingular Wireless Site BA-350-02, "California Avenue Caltrain Station", Palo Alto, California (letter report)
S-033281	2005	Supernowicz, Dana E.	Cultural Resource Study of the Middlefield & Meadow Dr. (Achieve School) Project, Cingular Wireless Site No. SCFCCA2074F, 3860 Middlefield Road, Palo Alto, Santa County, California 94303
S-008345	1980	Melandry, Mara	Archaeological Survey Report, 04-SCL-101, Portions of P.M. 38.3/52/5, Improvements to Route 101 between Route 17 and Embarcadero Road
S-012528	1991	Garaventa, Donna, Rebecca L. Anastasio, Stuart A. Guedon, Sondra Jarvis, Lisa A. Pujol, Steven J. Rossa	Cultural Resources Assessment for 1990 General Plan Update, City of Mountain View, Santa Clara County, California
S-032250	2003	Lapin, Philippe	Historic Property Survey Report, Mission Bells Project, State Route 82/Interstate 101, San Mateo and Santa Clara Counties, California

Survey #	Date	Author	Title
S-003123	1975	Stephen A. Dietz	An Assessment of the Archaeological and Paleontological Resources as May be Impacted by the South Bay Dischargers Authority's Proposed Joint Outfall Pipeline
S-003163	1973	Stephen A. Dietz	An archaeological reconnaissance of the proposed Dumbarton Bridge replacement project (letter report)
S-004411	1977	Stephen A. Dietz	Archaeological Reconnaissance and Literature Survey for the City of Palo Alto Regional Wastewater Treatment Works
S-007545	1985	David Chavez	Adobe Creek Mausoleum, Alta Mesa Memorial Park, Palo Alto (letter report)
S-012528	1990	Donna M. Garaventa, Rebecca L. Anastasio, Stuart A. Guedon, Sondra Jarvis, Lisa A. Pujol, and Steven J. Rossa	Cultural Resources Assessment for 1990 General Plan Update, City of Mountain View, Santa Clara County, California
S-020135	1997	Robert Cartier	Archaeological Testing at 4277 Miranda Avenue in the City of Palo Alto, California
S-020550	1998	Barry A. Price	Cultural Resources Assessment, Pacific Bell Mobile Services Facility SF-614-03, Palo Alto, Santa Clara County, California (letter report)
S-024125	2000	Archaeological Resource Management	Cultural Resources Evaluation, Property at #797 and #807 Matadero Avenue, Palo Alto, CA
S-024987	2001	Colin Busby	Archaeological Literature Search - HOV Lanes (letter report)
S-026604	2000	William Roop	A Cultural Resources Evaluation of the Lands of Midgal, 797 and 807 Matadero Road, Palo Alto, California

Survey #	Date	Author	Title
S-033061a	2006	Nancy Sikes, Cindy Arrington, Bryon Bass, Chris Corey, Kevin Hunt, Steve O'Neil, Catherine Pruett, Tony Sawyer, Michael Tuma, Leslie Wagner, and Alex Wesson	Cultural Resources Final Report of Monitoring and Findings for the Qwest Network Construction Project, State of California
S-033061b	2007	Nancy E. Sikes	Final Report of Monitoring and Findings for the Qwest Network Construction Project (letter report)
S-033545	1994	National Park Service	Draft Comprehensive Management and Use Plan and Environmental Impact Statement, Juan Bautista de Anza National Historic Trail, Arizona and California
S-034171	2007	Miley Paul Holman	Archaeological Backhoe Testing for Cultural Resources at the 901 San Antonio Road Project Area, Palo Alto, Santa Clara Couty, California (letter report)
S-034938	2008	Carolyn Losee	Cultural Resources Investigation for Project SNFCCA2512 "Stanford/Cameron Campus Temp" 700 Bowdoin Street, Stanford, Santa Clara County, California 94305, EBI Project 61082128
S-035728	2009	Carolyn Losee	Cultural Resources Analysis for AT&T CN3637-A "Foothill Research Center", 4005 Miranda Avenue, Palo Alto, Santa Clara County, California
S-036055	2009	Carolyn Lossee	Collocation ("CO") Submission Packet FCC Form 621, Project Name: Facebook; Project Number: AT&T Mobility CN5155
S-036303	2009	Denise Jurich, Jesse Martinez, and Emilie Zelazo	Phase II Archaeological Evaluation of Archaeological Site CA-SCL-585, United States Department of Veteran Affairs, Palo Alto Division Medical Campus, Palo Alto, California

Survey #	Date	Author	Title
S-036487	2009	Carolyn Losee	Cultural Resources Investigation for Clearwire Site #CA-SJC0033-D "Eastwick Company", 2696 Marine Way, Mountain View, Santa Clara County, California 94043
S-036518	2009	Marty Arbunich, Adriene Biondo, Barry Lee Brisco, Jane Clemmons, Merritt Colman, Wally Fields, Stephanie Raffel, Carroll Rankin, and Paul Adamson	The Eichler Homes: Context Study
S-036518a	1988	Merle Dean	Joseph Eichler and the Explosion of Post-War Domestic Mass Production in the San Francisco Bay Area, 1950 - 1965
S-036518b	1997		Context Statement: Sunnyvale's Early Eichler Developments
S-036518c	2001	Marty Arbunich and Barry Brisco	Castro Valley, Eichlers
S-036670	2009	Brian Hatoff	Verizon Cellular Communications Location Site - Meadow and Middlefield; 3672 Middlefield Road, Palo Alto, CA 94303
S-036762	2010	Carrie Wills	Cultural Resources Record Search and Site Vistit for Clearwire Candidate CA-SJC0048C (Sprint Midtown), 2701 Middlefield Road, Palo Alto, Santa Clara County, California
S-036910	2010	Carolyn Losee	Collocation ("CO") Submission Packet, FCC Form 621, Former Offices of Beckham Coulter, Inc., 1050 Page Mill Road, Palo Alto, California 94306
S-037074	2008	Adrian Whitaker	Extended Phase I Testing for the U.S. 101 Auxiliary Lanes (Route 85 to Embarcadero Road) Project, Santa Clara County, California, 04-SCL-101 PM 52-17-48.97 EA 04-4A330O
S-037287	2010	Lorna Billat and Dana Supernowicz	Collocation ("CO") Submission Packet, FCC Form 621, Arastradero Apartments, SF44919C
S-037483	2010	Carrie Wills	Cultural Resources Records Search and Site Visit for T-Mobile West Corporation, a

Survey #	Date	Author	Title
			Delaware Corporation, Candidate SF54260F (Light Foothill Expressway), Page Mill Road and Foothill Expressway, Palo Alto, Santa Clara County, California (letter report)
S-037748	2010	Heidi Koenig	G.A.R.-Field Park. Mountain View, Santa Clara County, Archaeological Survey Report
S-038085	2010	Aniela Travers	Cultural Resources Analysis, Coyote Hill/SFO-4530, 1501 Page Mill Road, Palo Alto, Santa Clara County, California 94304
S-039088	2010	Colin I. Busby	Cultural Resources Review - Records Search, Limited Literature Review, and Native American Consultation, Sewer Rehabilitation Project - East Palo Alto Sanitary District, Santa Clara County (letter report)
S-039469a	2012	Neal Kaptain	Archaeological Survey Report for the San Mateo County SMART Corridors Project, Segment III, Redwood City, Atherton, Menlo Park, East Palo Alto, and Palo Alto, San Mateo County and Santa Clara County, California; EA #4A9201; EFIS #0400001169; Caltrans Dist
S-039469b	2012	Neal Kaptain	Post-Review Discovery and Monitoring Plan for the San Mateo County SMART Corridors Project, Segment III, Redwood City, Atherton, Menlo Park, East Palo Alto, and Palo Alto, San Mateo County and Santa Clara County, California; EA #4A9201; EFIS #0400001169,
S-039620	2012	James M. Allan	Archaeological Monitoring of B/4B Project, Palo Alto, CA (letter report)
S-039718	2012	Wayne H. Bonner and Kathleen A. Crawford	Direct APE Historic Architectural Assessment for T-Mobile West, LLC Candidate SF04614A (Stanford Inn), 531 Stanford Avenue, Palo Alto, Santa Clara County, California (letter report)
S-039735	2012	Jessica Tudor and Kathleen A. Crawford	Cultural Resources Records Search and Site Visit Results for T-Mobile West, LLC Candidate SF04614A (Stanford Inn), 531 Stanford Avenue, Palo Alto, Santa Clara

Survey #	Date	Author	Title
			County, California (letter report)
S-041536	2001	Michael Corbett and Denise Bradley	Final Survey Report, Palo Alto Historical Survey Update, August 1997- August 2000
S-041600	2012	Dana Supernowicz	Cultural Resources Study of the Palo Alto Odas Project, Nodes P1N1B, P1N7A,P1N10B, P1N13A,P1N4A,P1N16A,P1N16B,P1N21A,P1N29AP1N34A, Palo Alto, Santa Clara County, CA
S-043328	2013	Lorna Billat and Dana Supernowicz	New Tower Submission Packet; Baylands/Palo Alto; CNU4060;1901 Embarcadero Road, Santa Clara, CA; Architectural Evaluation Study of the Baylands/Palo Alto Project, AT&T Mobility site #CNU4060, 1901 Embarcadero Rd, Palo Alto, Santa Clara County, CA 94303
S-043758	2013	Sharon A. Waechter	Excavations at CA-SCL-628 on Matadero Creek, Palo Alto, California
S-044044b	2014	Heidi Koenig	Archaeological Survey Report Highway 101 Overcrossing Project Palo Alto, Santa Clara County, CA County Post Mile SCL 50.684

The records search indicated that one previously recorded resource (a historic railroad, P-43-000928) crosses the project APE and is discussed below (Figure 6). Fifteen (15) other previously recorded archaeological sites are located within ¼-mile of the project area (Table 7). Twelve of the sites are prehistoric shell middens, three are prehistoric quarry areas and one is a historic railroad. The shell midden sites are evidence of significant prehistoric settlement of the area and appear to be along Matadero and Barron creeks. The quarry sites are located in the lower margins of the Los Altos Hills.

P-43-000928

The resource is a segment of the Southern Pacific Railroad that is now Caltrain (Corbett 1995). Originally, the line was the San Francisco and San Jose Railroad (SF&SJ) that began operation in 1864. In the 20th century the line was popularly known as the Southern Pacific "Ocean View Line" (Corbett 1995), In the late 1950s, the Southern Pacific Railroad rehabilitated the line with heavier rails and to more exacting engineering standards to operate it as a commuter line. The

Table 7. Cultural resources within ¼-mile of the project area

Primary Number	Trinomial	Site Description	Recording Events[5]
P-43-000023	CA-SCL-000003	Prehistoric midden/ lithic scatter; burials; hearths/pit features; habitation debris	Slaymaker*); 1900 (Unknown*, Stanford University); 1949 (Pilling*); 1984; 1985 (Barbara Bocek, Stanford University); 2010 (D. Daly, K. Turner, Stanford University)
P-43-000055	CA-SCL-000036	Prehistoric midden/ habitation debris	1951 (D.W.L.); 1987 (Barb Bocek, Stanford University)
P-43-000441	CA-SCL-000439/H	Prehistoric midden/ lithic debris	1978 (C. Desgrandchamp, C. Sutton); 2007 (Michael Darcangelo, Far Western Anthropological Research Group, Inc.); 2008 (Adrian Whitaker, Far Western Anthropological)
P-43-000580	CA-SCL-000585	Prehistoric midden/ lithic scatter; burials; habitation debris	1985 (Bocek / Rutherford); 2009 (Jurich, Martinez, Zelazo)
P-43-000591	CA-SCL-000596	Prehistoric midden/ lithic scatter; burials; habitation debris	1986 (Barbara Bocek, Stanford University)
P-43-000617	CA-SCL-000622	Prehistoric midden/habitation debris	1987 (Barbara Bocek, Stanford University)
P-43-000619	CA-SCL-000624	Prehistoric midden/ habitation debris	1987 (CARTIER / ENGLAND, De Anza College Field Studies)
P-43-000627	CA-SCL-000700	Prehistoric midden/ habitation debris	1990 (Barbara Bocek, Stanford University)
P-43-000634	CA-SCL-000716	Prehistoric midden/ lithic scatter; habitation debris	1991 (Barbara Bocek, Stanford University)

[5] References marked with an * are cited in others documents and were not in WSA's possession.

Primary Number	Trinomial	Site Description	Recording Events[5]
P-43-000662	CA-SCL-000628	Prehistoric midden/lithic scatter; hearths/pit features; habitation debris	1987 (Barb Bocek, Stanford University); 2013 (S. Waechter, M. Darcangelo, FWARG)
P-43-000663	CA-SCL-000630	Prehistoric quarry/ lithic scatter; petroglyphs	1987 (Barb Bocek, Stanford University); 2010 (D. Daly, K. Turner,, Stanford University)
P-43-000664	CA-SCL-000631	Prehistoric quarry/ lithic scatter	1987 (Barb Bocek, Stanford University); 1987 (Barb Bocek, Stanford University); 2010 (D.Daly, K.Turner, Stanford University); 2010 (D. Daly, K. Reinhart, K. Turner, Stanford University)
P-43-000670	CA-SCL-000708	Prehistoric midden/ habitation debris	1990 (Barb Bocek, Stanford University)
P-43-000928	CA-SCL-898H	Historic railroad/berm and tracks	1995 (Michael Corbert)
P-43-002626	N/A	Shell scatter, possible midden	2012 (Neal Kaptain, LSA)
P-43-002656	CA-SCL-000900	Possible prehistoric quarry/ lithic scatter	2011 (D. Daly, K. Turner, Stanford University)

Southern Pacific operated this commuter service with varying degrees of financial success through the 1970s, finally filing for abandonment of service in the late 1970s (Corbett 1995). In the early 1980s, the State of California leased much of the line to operate what it called "Caltrain." The State of California continued to operate the facility, formally known as the Peninsula Commute Service through the 1980s. In 1991, however, the state transferred its interest to a Joint Powers Board, representing affected counties and municipalities, chiefly Santa Clara and San Mateo counties (Corbett 1995). Caltrain is governed by the Peninsula Corridor Joint Powers Board (PCJPB), which consists of agencies from the three Caltrain counties. The member agencies are the City and County of San Francisco, SamTrans and the Santa Clara Valley Transportation Authority.

Segments and numerous features (e.g., bridges, culverts, etc.) of this portion of the railroad line have been recorded (Corbett 1995a,b,c,d,e,f,g). None of the evaluated features have been recommended as eligible for the NRHP. Because the line was substantially rebuilt in the 1950s

Figure 6: Record Search Results

Confidential (Not Included in this Document)

and again in the 1990s in selected locations, where tracks, ties, and plates were replaced, it has been recommended as ineligible for listing in the NRHP (Corbett 1995a,b,c,d,e,f,g).

4.0 Native American Consultation

When the Native American contacts were contacted originally in 2007 regarding this project, no responses to letters were received. Follow up phone calls elicited a few general responses for use of Native American monitors during construction of the pipeline (Strother et al. 2008). Due to changes in the original project, the current WSA scope of work required that Native American consultation be reinitiated. WSA contacted the Native American Heritage Commission (NAHC) by email on October 22, 2014, requesting information on sacred lands and a contact list of local tribal representatives. A response was received from the NAHC on November 5, 2014 noting, "A record search of the sacred land file has failed to indicate the presence of Native American cultural resources in the immediate project area." The letter also provided a list of Santa Clara County Native American Contacts. A list of Native American contacts was included in the response (Jakki Kehl; Irene Zwierlein, Amah/Mutsun Tribal Band; Katherine Erolinda Perez; Michelle Zimmer, Amah Mutsun Tribal Band of Mission San Juan Bautista; Valentin Lopez, Amah Mutsun Tribal Band; Linda G. Yamane; Ann Marie Sayers, Indian Canyon Mutsun Band of Costanoan; Rosemary Cambra, Muwekma Ohlone Indian Tribe of the SF Bay Area; Andrew Galvan, The Ohlone Indian Tribe; and Ramona Garibay, Trina Marine Ruano Family). WSA contacted the Native American representatives by letter, on November 18, 2014, informing them of the project. Follow-up phone calls to the Native American representatives were placed on December 2, 2014. Irene Zwierlein and Ramona Garibay agreed with WSA recommendations, Ann Marie Sayers recommended that Native American monitors be used in addition to archaeological monitors, and Rosemary Cambra requested more information about the project. No other comments or recommendations were received.

5.0 Survey Methods

WSA Staff Archaeologist Thomas Young conducted a field reconnaissance of the proposed Palo Alto Recycled Water Project on October 24, 2014. Because the Project APE is extensively urbanized and built up area very little exposed ground surface was available for viewing. Most of the exposed ground surface appears in landscaped areas along roadways and parking surfaces. The pipeline (both backbone and lateral) alignments are predominately located within asphalted roadways, the booster pump station footprint is within an asphalted parking area next to the Mayfield soccer fields, and approximately 75 percent of the potential pump locations with the RWQCP are covered with concrete or asphalt. Even the creek crossings are areas with almost no ground visibility, as all of the creeks are channelized and concreted. Mr. Young drove the entire APE stopping to investigate any exposed ground surface for the presence of prehistoric or historic artifacts and any evidence for the presence of cultural soils such as shell midden. He also inspected the APE for standing historic structures that may be within the Project APE.

One hundred percent of all exposed ground surface within the Project APE was examined for the presence of historic or prehistoric site indicators. Historic site indicators include, but are not limited to foundations, fence lines, ditches, standing buildings, objects or structures such as sheds, or concentrations of materials at least 50 years in age, such as domestic refuse (glass bottles, ceramics, toys, buttons or leather shoes), or refuse from other pursuits such as agriculture (e.g., metal tanks, farm machinery parts, horse shoes) or structural materials (e.g., nails, glass window panes, corrugated metal, wood posts or planks, metal pipes and fittings, etc.). Prehistoric site indicators include, but are not limited to areas of darker soil with concentrations of ash, charcoal, bits of animal bone (burned or unburned), shell, flaked stone, ground stone, or even human bone.

6.0 Results of the Field Survey

The survey will be discussed in order of backbone pipeline and lateral pipelines, the two pipeline options for the proposed pipeline, the booster pump station at Mayfield Soccer Fields, and finally the RWQCP.

6.1 Backbone Pipeline

The APE for the pipe backbone encompasses land developed for both residential and commercial use. No undeveloped parcels were encountered during the survey of the proposed backbone pipeline APE.

The northeastern half of the proposed backbone pipeline APE is primarily residential. This section of the APE includes Fabian Way, East Meadow Drive, Cowper Street, El Dorado Avenue and El Carmelo Avenue (see Appendix B: Photo 1). This residential area contains single-family homes with landscaped grass lawns. Commercial office buildings comprise the far eastern section of East Meadow Road (just west of Highway 101). As a result of the density of development and paved streets in this section of the proposed backbone pipeline APE, ground visibility is lacking due to modern development and landscaping. No cultural resources were observed during the survey.

The southwestern half of the proposed backbone pipeline APE consists primarily of commercial development, composed of office buildings, a city park and complexes of buildings for various law and technology firms (see Appendix B: Photo 2). This section of the APE includes Alma Street, Page Mill Road, El Camino Real, Hansen Way, Hanover Street, California Avenue, Hillview Avenue and Miranda Avenue. Similar to the eastern section of the proposed backbone pipeline APE, ground visibility is lacking due to modern development and landscaping. No cultural resources were observed during the survey.

Four creek crossings are along the proposed backbone pipeline APE.

- Along East Meadow Drive just west of Fabian Way, the proposed backbone pipeline APE crosses Adobe Creek. The creek is channelized with concrete banks at the crossing. No cultural material was observed at this creek crossing.
- On Cowper Street west of East Meadow Drive, the proposed backbone pipeline APE crosses Barron Creek (Appendix B: Photo 3). The creek is channelized with concrete banks at the crossing. No cultural material was observed at this creek crossing.
- On Cowper Street east of El Dorado Avenue, the proposed backbone pipeline APE crosses Matadero Creek (Appendix B: Photo 4). The creek is channelized with concrete banks at the crossing. No cultural material was observed at this creek crossing.
- On Hillview Avenue, between Hanover Street and Foothill Expressway, the proposed backbone pipeline APE crosses Matadero Creek (Appendix B: Photo 5). The creek crossing at Hillview Avenue has dirt banks reinforced with concrete "pillows" for erosion control. There are a lot of trees and low plants along the bank. The creek is redirected underground on the east side of Hillview Avenue. No cultural material was observed at this creek crossing.

A railroad crossing is also along the backbone pipeline APE. The APE crosses the railroad from Alma Street to the north end of Page Mill Road. Alma Street is paved as is Page Mill Road (see Appendix B: Photo 6). The railroad tracks are fenced and the survey did not enter into the fenced railroad right-of-way. Exposed ground surface was highly disturbed and no cultural material was observed at this railroad crossing.

6.2 Pipeline Laterals

A total of 10 pipe laterals are included in the APE. These include areas on (1) Middlefield Road, (2) a section of East Meadow Road southwest of the intersection with Cowper Street, (3) Dymond Court south of Cowper Street, (4) Cowper Street west of the intersection with El Dorado, (5) the mall entrance between El Camino Real and Hanover Street on the west side of Page Mill Road, (6) Hanover Street west of Page Mill Road and continuing south on S. California Avenue, (7) Page Mill Road south of Hanover Street and continuing east on Porter Street, (8) along the north side of Foothill Expressway (Miranda Avenue) east of Hillview Avenue continuing north on Arastradero Road, (9) the southern end of Hansen Way, and (10) from Arastradero Road southwest from the intersection with Hillview Avenue continuing northwest on Deer Creek Road continuing to the east through the business park back to Hillview Avenue. The proposed pipeline laterals for the most part are in paved roadways though landscaped residential areas that offered no ground visibility except in strips of landscaped areas. No cultural material was observed along this route.

Some of the laterals cross commercial areas that are also paved. The easternmost pipeline lateral in the commercial area runs southeast from the intersection of El Camino Real and Page Mill Road to the intersection of El Camino Real and Hansen Way (Appendix B: Photo 7). At this intersection, the pipeline will turn and continue southwest along Hansen Way to the bend in the road. This area is strictly commercial, with paved roads and landscaped green areas. No cultural material was observed along this route. Another pipeline lateral is proposed for a paved parking lot between two office buildings on Page Mill Road between El Camino Real and Hanover Street. This parking lot is completely paved and no cultural material was observed. An additional pipeline lateral will be placed on Hanover Street (the section northwest of Page Mill Road) and will continue south onto California Avenue. The portion of this pipeline lateral on Hanover Street is located in a commercial district, which changes to residential as the proposed route turns on to California Avenue (Appendix B: Photo 8). The residential portion of California Avenue is made up of homes with landscaped yards. No cultural material was observed in this section.

A pipeline lateral is proposed for the southernmost section of Page Mill Road. At the intersection of Page Mill Road and Porter Drive, the pipe turns east and continues until it terminates at the intersection of Porter Drive and Hillview Avenue (Appendix B: Photo 9). This section of pipeline lateral continues through a developed commercial area and traversed into residential neighborhoods, with paved sidewalks and landscaped yards. The ground visibility was better in these areas. No cultural material was observed on this section of pipe lateral.

A proposed pipeline lateral will run southeast from the intersection of Hillview Avenue and Foothill Expressway to the intersection of Foothill Expressway to Arastradero Road. It will run along the north side of the Expressway along Miranda Avenue. At the intersection with Arastradero, the lateral turns and continues east along Arastradero Road where it passes Georgia Avenue and terminates at the intersection of Arastradero Road and Willmar Drive (Appendix B: Photo 10). The majority of this proposed pipeline lateral runs through commercial property, a small portion of which is residential. The commercial area running along the Foothill Expressway and continuing along Arastradero Road consists of the Palo Alto Veterans Affairs Hospital and Henry M. Gunn High School. The easternmost finger of this pipeline lateral, on Arastradero Road between Georgia Avenue and Willmar Drive, is residential on the west side of the street, while the east is Alta Mesa Cemetery. No cultural material was observed along this pipeline lateral.

Another proposed pipeline lateral runs along Hillview to the south where it intersects with Arastradero Road. From here it continues west along Arastradero Road to Deer Creek Road and turns to the north. It continues to the end of the business park where it turns to the east along the north side of the business park. It continues back to Hillview Avenue. The majority of this proposed pipeline lateral is on paved roads around commercial property. The stretch from Deer Creek Road to Hillview Avenue crosses along the southern edge of a horse pasture that is fenced private property. The surveyor did not enter the fenced property. (Appendix B: Photo 11). No cultural material was observed along this pipeline lateral.

Two creek crossings are along the proposed pipeline laterals APE.

- Along Middlefield Road just northwest of Ensign Way, the proposed pipeline lateral APE crosses Adobe Creek (Appendix B: Photo 12). The creek is channelized with concrete banks at the crossing. No cultural material was observed at this creek crossing.
- On Miranda Avenue just west of Arastradero Road, the proposed pipeline lateral APE crosses Barron Creek (Appendix B: Photo 13). The creek is exposed on both the north and south sides of Foothill Expressway, which parallels Miranda Avenue to the south. The water level of the creek is low and not moving. The creek banks are dirt that has been reinforced with concrete "pillows" for erosion control near the road. At Arastradero Road the creek has been redirected underground, and at the surface there is a dirt bike/pedestrian pathway. No cultural material was observed at this creek crossing.

6.3 Pipeline Option One

The APE of alignment Option 1 begins at the intersection of East Bayshore Road and crosses US-101 to the south. The APE then continues along Fabian Way for a distance of approximately 650 feet (Appendix B: Photo 14). The area of Fabian Way within the APE of this alignment option is commercial (Appendix B: Photo 15). Ground visibility here is poor. No cultural material was observed within Option 1 alignment.

6.4 Pipeline Option Two

Alignment Option 2 includes a portion of El Camino Real (just south of Page Mill Road) and continues onto Hansen Way (Appendix B: Photo 16). This portion of the APE is developed as a commercial area and includes a business Park with manicured and landscaped lawns with redwoods and small street trees. Ground visibility here is poor. All land within alignment Option 2 was developed. No cultural materials were observed within alignment Option 2.

6.5 Booster Pump Station at Mayfield Soccer Fields

A booster pump station will be required adjacent to the western half of the backbone pipeline APE. The booster pump station is located on the southeastern corner of the intersection of Page Mill Road and El Camino Real at the Mayfield Soccer Fields (Appendix B: Photo 17). The booster pump station location was inspected during the survey. Ground visibility was less than 5 percent here. There was a little bit of exposed ground among a landscaped area, which was investigated for cultural resources; visibility in the landscaped area was approximately 60 percent. No cultural material was observed at this location.

6.6 Regional Water Quality Control Plant

Two areas at the RWQCP location were surveyed: (1) the connection pipeline and (2) three possible locations for aboveground tanks installation on the RWQCP property.

The connection pipeline is located along the E. Bayshore Road, within an area of business parks. The area is paved and landscaped, but the wetlands are just to the northwest of the proposed connection pipeline. Ground visibility here is poor with only landscaped areas open. No cultural material was observed.

The RWQCP is located south of Embarcadero Road and east of Embarcadero Way, and is located on fill. The sloped and mounded topography suggests that soil was moved from other areas within the RWQCP property, possibly related to facility expansion over the years. There are three possible locations for the pump station installation. One location is in the basement of the existing administrative building. The other two locations are on paved portions of the property (Appendix B: Photos 18 and 19). One is on the northeast side of the administration building, and the other location is on the northeast side in the large chlorine contact tank, which dominates the northern portion of the property. The area was investigated for the historic debris that was reported in 2007 as being in the north and northwestern portions of the plant property (WSA 2007). During the survey, no trace of the debris could be found. Ground visibility was less than 20%, and was covered by eucalyptus tree leaf litter. They historic material apparently was collected in 2007. There is no archival data to suggest the presence of historic resources and their presence is considered unlikely.

7.0 Impact Assessment and Recommendations Regarding Discoveries during Construction

7.1 NRHP/CRHR Criteria for Evaluation

Under the National Environmental Policy Act (NEPA), federal agencies have the responsibility to "preserve important historic, cultural and natural aspects of our national heritage..." (Section 101(b)(4), 42 U.S.C. § 4331). The 1966 National Historic Preservation Act (NHPA), as amended, requires Federal agencies to take into account the effects of their undertakings on "historic properties" (i.e., cultural resources eligible for or listed on the National Register of Historic Places [NRHP]), which is done through the Section 106 process as established in 36 CFR Part 800. NEPA review and NHPA Section 106 compliance are typically coordinated, when a Federal action reviewed under NEPA constitutes an undertaking requiring NHPA Section 106 compliance.

The NRHP, created under the NHPA, is the federal list of historic, archaeological, and cultural resources worthy of preservation and is maintained and expanded by the National Park Service on behalf of the Secretary of the Interior. The Office of Historic Preservation in Sacramento, California, administers the local NRHP program under the direction of the State Historic Preservation Officer. Resources listed in the NHRP include districts, sites, buildings, structures, and objects that are significant in American history, prehistory, architecture, archaeology, engineering, and culture.

To guide the selection of properties included in the NRHP, the National Park Service has developed the NRHP Criteria for Evaluation. The criteria are standards by which every property that is nominated to the NRHP is judged. The quality of significance in American history, architecture, archaeology, and culture is possible in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, material, workmanship, feeling, and association and that meet one of the following criteria:

- **Criterion A**: A property is associated with events that have made a significant contribution to the broad patterns of our history; or
- **Criterion B**: A property is associated with the lives of persons significant in our past; or
- **Criterion C**: A property embodies the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, or that possesses high artistic values, or that represents a significant and distinguishable entity whose components make lack individual distinction; or
- **Criterion D**: A property has yielded, or may be likely to yield, information important in prehistory or history (36 CFR Part 60).

Under the California Environment Quality Act (CEQA) both public and private projects with financing or approval from a public agency must assess the project's effects on cultural resources (Public Resources Code Section 21082, 21083.2 and 21084 and California Code of Regulations 10564.5).

Cultural resources are buildings, sites, humanly modified landscapes, traditional cultural properties, structures, or objects that may have historical, architectural, cultural, or scientific importance. CEQA states that if a project will have a significant impact on important cultural resources, then project alternatives and mitigation measures must be considered. However, only significant cultural resources need to be considered in the mitigation plans.

CEQA defines significant historical resources as "resources listed or eligible for listing in the California Register of Historical Resources (CRHR)" (Public Resources Code Section 5024.1). A property may be considered historically significant if it meets the following criteria for listing on the CRHR:

1. It is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage;
2. It is associated with the lives of persons important to California's past;
3. It 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. It has yielded or is likely to yield information important in prehistory or history (Public Resources Code Section 5024.1).

Integrity

In addition to meeting one or more of the four specific criteria listed above, a historic property or historic resource must possess "integrity" to qualify for listing in either the NRHP or the CRHR. Integrity is generally evaluated with reference to qualities including location, design (i.e., site structure), materials, workmanship, setting, feeling, and association. A potentially eligible site must retain the integrity of the values that would make it significant. Typically, integrity is indicated by evidence of the preservation of the contextual association of artifacts, ecofacts, and features within the archaeological matrix (as would be required under Criterion D/4) or the retention of the features that maintain contextual association with historical developments or personages that render them significant (Criteria A, B, or C/1, 2, or 3). Evidence of the preservation of this context is typically determined by stratigraphic analysis and analysis of diagnostic artifacts and other temporal data (e.g., obsidian hydration, radiocarbon assay) to ascertain depositional integrity or by the level of preservation of historic and architectural features that associate a property with significant events, personages, or styles.

Integrity refers both to the authenticity of a property's historic identity, as shown by the survival of physical characteristics that existed during its historic period, and to the ability of the property to convey its significance. This is often not an all-or-nothing scenario (determinations can be subjective); however, the final judgment must be based on the relationship between a property's features and its significance.

7.2 Assessment and Recommendations

WSA conducted the archaeological survey of the Project APE for the Palo Alto Recycled Water Facility Project on October 24, 2014.

One resource (P-48-000928) crosses the backbone pipeline APE. It is the Caltrain line that follows the original alignment of the San Francisco and San Jose Railroad (SF&SJ). None of the other previously recorded archaeological sites are within the project APE. The archaeological survey of the project APE failed to identify any previously unrecorded cultural resources.

WSA recommends the following actions.

- San Francisco and San Jose Railroad (P-48-000928) -- the project APE crosses the railroad alignment from Alma Street to the northern end of Page Mill Road. Although the property follows the original alignment of the SF&SJ, which "is associated with events that have made a significant contribution to the broad patterns of our history" (Criterion A) i.e., early railroad construction, the tracks have been replaced and upgraded at least twice (in the 1950s and 1990s) since the original railroad was constructed (Corbett 1995a-g) and no longer retains its integrity its design, materials and workmanship. In addition, because of intense urbanization the railroad does not retain its integrity of setting, feeling, and association. This segment of the property cannot be recommended as eligible for listing in the NRHP. Project construction plans to avoid the property by using a trenchless method that will bore beneath the railroad tracks. The Project will not affect the railroad. No further action is recommended.

- The results of the archaeological sensitivity modeling of the project area identified seven areas of either high or high to moderate archaeological sensitivity.

    - The Adobe Creek crossing on East Meadow Drive is located in an area of high archaeological sensitivity
    - The Adobe Creek crossing along Middlefield Road is located in an area of high archaeological sensitivity
    - The Barron Creek crossing along Cowper Street is located in an area of high archaeological sensitivity
    - The Matadero Creek crossing along Cowper Street is located in an area of high archaeological sensitivity
    - The lateral line along Arastadero Road northeast from the intersection with Miranda Avenue is located in an area of high archaeological sensitivity
    - The Matadero Creek crossing along Hillview Avenue is located in an area of high to moderate archaeological sensitivity
    - The Barron Creek crossing along Miranda Avenue is located in an area of high to moderate archaeological sensitivity

  Due to urbanization and channelization of creeks, ground visibility in these areas was minimal during the archaeological pedestrian survey. Consequently, the field reconnaissance was unable to assess the potential that historic properties are present in these areas. Therefore, WSA recommends that a program of sub-surface testing be conducted to determine whether buried resources are present within the areas of high or high to moderate archaeological sensitivity that will be impacted by Project construction. Only those locations where design confirms that the proposed pipeline would be buried at archaeologically sensitive locations will require subsurface testing. A testing program will be developed to determine the best approach for each location, considering the physical constraints of the urban setting (e.g., structures, traffic). The testing program could consist of multiple core extractions at individual sites; the locations and depths of the boreholes would be determined on the basis of projected depths of excavation at the individual work areas. A qualified archaeologist would monitor the testing efforts, and inspect the cores for prehistoric archaeological site indicators (e.g., chipped chert and obsidian tools, and tool manufacturing waste flakes, grinding implements such as mortars and pestles, and darkened soil that contains dietary debris such as bone fragments and shellfish remains) and historic site indicators (e.g., ceramics, glass, wood, bone, and metal remains).

If the findings of the subsurface testing are negative, then no further actions (e.g., further testing or archaeological monitoring) would be recommended as necessary for NHPA Section 106 compliance. If the findings of the subsurface testing are positive, then a qualified archaeologist will develop an archeological data recovery plan (ADRP) in consultation with the City, the lead Federal agency, the SHPO and other appropriate consulting parties, as applicable, in accordance with the requirements of 36 CFR Part 800. The ADRP shall identify how the proposed data recovery program will be used to evaluate and preserve the significant information the archaeological resource is expected to contain. That is, the ADRP will identify what scientific/historical research questions are applicable to the expected resource, what data classes the resource is expected to possess, and how the expected data classes would address the applicable research questions. Implementation of the ADRP through the development and execution of an appropriate agreement document by the lead Federal agency, the SHPO, the City of Palo Alto, as local Lead Agency, and any other identified signatories, would satisfy the requirements of NHPA Section 106 as outlined at 36 CFR § 800.6. Whether the results of subsurface testing are negative or positive, if Federal funding for the Project is approved, full compliance with Section 106 of the NHPA as determined by the lead Federal agency will be required prior to Project construction.

- .In the event that Native American human remains or funerary objects are discovered, the provisions of the California Health and Safety Code should be followed. Section 7050.5(b) of the California Health and Safety Code states:

  > In the event of discovery or recognition of any human remains in any location other than a dedicated cemetery, there shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent remains until the coroner of the county in which the human remains are discovered has determined, in accordance with Chapter 10 (commencing with Section 27460) of Part 3 of Division 2 of Title 3 of the Government Code, that the remains are not subject to the provisions of Section 27492 of the Government Code or any other related provisions of law concerning investigation of

> the circumstances, manner and cause of death, and the recommendations concerning treatment and disposition of the human remains have been made to the person responsible for the excavation, or to his or her authorized representative, in the manner provided in Section 5097.98 of the Public Resources Code.

The County Coroner, upon recognizing the remains as being of Native American origin, is responsible to contact the Native American Heritage Commission within 24 hours. The Commission has various powers and duties to provide for the ultimate disposition of any Native American remains, as does the assigned Most Likely Descendant. Sections 5097.98 and 5097.99 of the Public Resources Code also call for "protection to Native American human burials and skeletal remains from vandalism and inadvertent destruction." The lead federal agency and the City of Palo Alto, as local Lead Agency, will both be notified in the event human remains are encountered during implementation of the ADRP, in compliance with 36 CFR 800.13.

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William Self Associates, Inc. (WSA)

2007 Palo Alto Recycled Water Project Additional Facilities (letter report). Report prepared for RMC Water and Environment. Report prepared by William Self Associates, Inc., Orinda, CA.

Appendix A

NAHC Correspondence

STATE OF CALIFORNIA Edmund G. Brown, Jr., Governor

NATIVE AMERICAN HERITAGE COMMISSION
1550 Harbor Blvd.
West Sacramento, CA 95691
(916) 373-3710
Fax (916) 373-5471

November 5, 2014

Allen Estes
WILLIAM SELF ASSOCIATES
61d Avenida de Orinda
Orinda aCA 94563

By: FAX: 925-254-3553

3 Pages

Re: Palo Alto Recycled Water project, Santa Clara County

Mr. Estes

A record search of the sacred land file has failed to indicate the presence of Native American cultural resources in the immediate project area. The absence of specific site information in the sacred lands file does not indicate the absence of cultural resources in any project area. Other sources of cultural resources should also be contacted for information regarding known and recorded sites.

Enclosed is a list of Native Americans individuals/organizations who may have knowledge of cultural resources in the project area. The Commission makes no recommendation or preference of a single individual, or group over another. This list should provide a starting place in locating areas of potential adverse impact within the proposed project area. I suggest you contact all of those indicated, if they cannot supply information, they might recommend others with specific knowledge. By contacting all those listed, your organization will be better able to respond to claims of failure to consult with the appropriate tribe or group. If a response has not been received within two weeks of notification, the Commission requests that you follow-up with a telephone call to ensure that the project information has been received.

If you receive notification of change of addresses and phone numbers from any of these individuals or groups, please notify me. With your assistance we are able to assure that our lists contain current information. If you have any questions or need additional information, please contact me at (916) 373-3713.

Sincerely,

Katy Wharton for

Debbie Pilas-Treadway
Environmental Specialist III

Native American Contacts
Santa Clara County
November 7, 2014

Jakki Kehl
720 North 2nd Street
Patterson , CA 95363
jakkikehl@gmail.com
510-701-3975
Ohlone/Costanoan

Katherine Erolinda Perez
P.O. Box 717
Linden , CA 95236
canutes@verizon.net
(209) 887-3415
Ohlone/Costanoan
Northern Valley Yokuts
Bay Miwok

Linda G. Yamane
1585 Mira Mar Ave
Seaside , CA 93955
rumsien123@yahoo.com
(831) 394-5915
Ohlone/Costanaon

Amah MutsunTribal Band
Valentin Lopez, Chairperson
P.O. Box 5272
Galt , CA 95632
vlopez@amahmutsun.org
(916) 743-5833
Ohlone/Costanoan
Northern Valley Yokuts

Amah MutsunTribal Band
Edward Ketchum
35867 Yosemite Ave
Davis , CA 95616
aerieways@aol.com
Ohlone/Costanoan
Northern Valley Yokuts

Amah MutsunTribal Band of Mission San Juan Bautista
Irene Zwierlein, Chairperson
789 Canada Road
Woodside , CA 94062
amahmutsuntribal@gmail.com
(650) 400-4806 Cell
(650) 332-1526 Fax
Ohlone/Costanoan

Amah MutsunTribal Band of Mission San Juan Bautista
Michelle Zimmer
789 Canada Road
Woodside , CA 94062
amahmutsuntribal@gmail.com
(650) 851-7747 Home
(650) 332-1526 Fax
Ohlone/Costanoan

Indian Canyon Mutsun Band of Costanoan
Ann Marie Sayers, Chairperson
P.O. Box 28
Hollister , CA 95024
ams@indiancanyon.org
(831) 637-4238
Ohlone/Costanoan

Muwekma Ohlone Indian Tribe of the SF Bay Area
Rosemary Cambra, Chairperson
P.O. Box 360791
Milpitas , CA 95036
muwekma@muwekma.org
(408) 205-9714
(510) 581-5194
Ohlone / Costanoan

The Ohlone Indian Tribe
Andrew Galvan
P.O. Box 3152
Fremont , CA 94539
chochenyo@AOL.com
(510) 882-0527 Cell
(510) 687-9393 Fax
Ohlone/Costanoan
Bay Miwok
Plains Miwok
Patwin

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resource Section 5097.98 of the Public Resources Code

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed Palo Alto Recycled Water project, Santa Clara County

Native American Contacts
Santa Clara County
November 7, 2014

Trina Marine Ruano Family	
Ramona Garibay, Representative	
30940 Watkins Street	Ohlone/Costanoan
Union City , CA 94587	Bay Miwok
soaprootmo@comcast.net	Plains Miwok
(510) 972-0645	Patwin

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resource Section 5097.98 of the Public Resources Code

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed Palo Alto Recycled Water project, Santa Clara County

WSA

Consultants in Archaeology and Historic Preservation

November 18, 2014

Jakki Kehl
720 North 2nd Street
Patterson, CA 95363

Re: Proposed Palo Alto Recycled Water Project, Santa Clara County

Dear Ms. Kehl,

William Self Associates, Inc. (WSA) has been contracted by RMC to conduct a cultural resources assessment for the Palo Alto Regional Water Quality Control Plant's expansion of its regional recycled water system in the City of Palo Alto. The project area is located within an unsectioned portion of Township 6S, Range 2W, in Santa Clara County, as depicted on the attached map.

A record search of the sacred land file conducted by the Native American Heritage Commission (NAHC) failed to indicate the presence of Native American cultural resources in the immediate project area. However, the NAHC provided your name as a person who may have knowledge of such resources in the project area.

WSA would appreciate receiving any comments you may have regarding cultural resources or sacred sites issues within the immediate project area. We will make sure the comments are provided as part of the environmental assessment of the project.

Thanks for your assistance.

Sincerely,

James M. Allan, Ph.D., RPA
Vice-President, Principal Project Director

Attachment

William Self Associates, Inc.
P.O. Box 2192
61d Avenida de Orinda
Orinda CA 94563
Phone: 925-253-9070
Fax: 925-254-3553
Email:jallan@williamselfassoc.com

Appendix B

Survey Photographs

Photo 1: View NE along East Meadow Dr. from the intersection wtih Middlefield Rd.

Photo 2: View SW along Page Mill Dr. south of El Camino Real.

Photo 3: View SW along Barron Creek at the Cowper Street crossing.

Photo 4: View NE along Matadero Creek at the Cowper Street crossing.

Photo 5: View NE along Matadero Creek at the Hillview Ave. crossing.

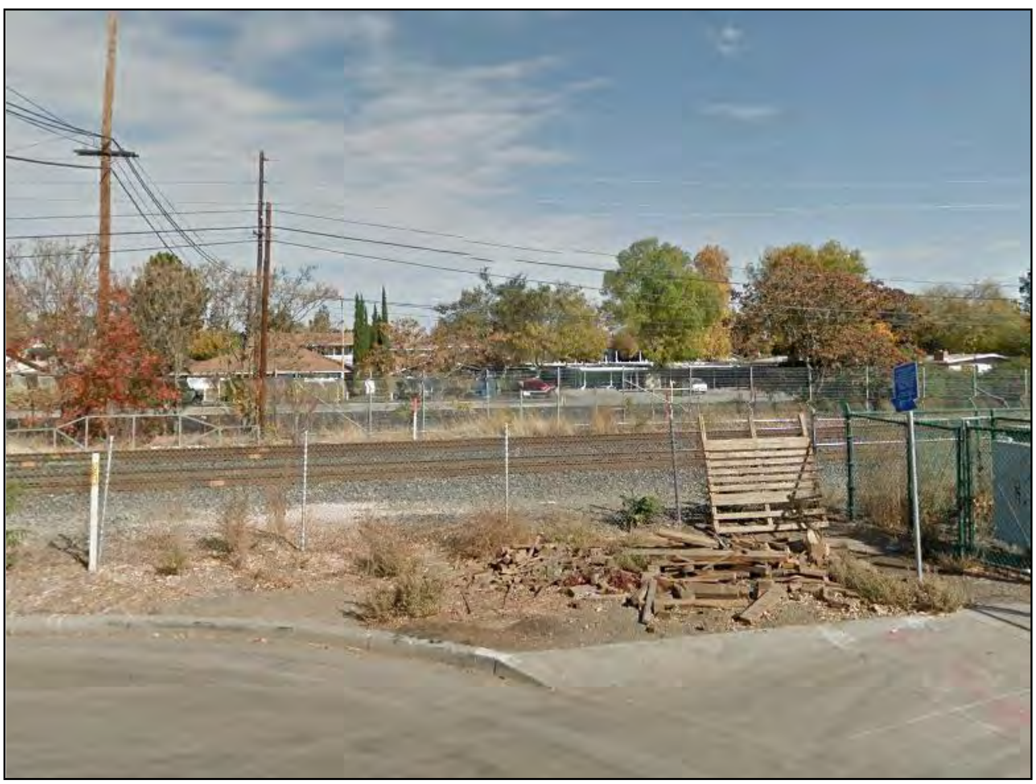

Photo 6: View N across Caltrain tracks from the north end Page Mill Dr.

Photo 7: View NW along El Camino Real from the intersection with Hansen Way.

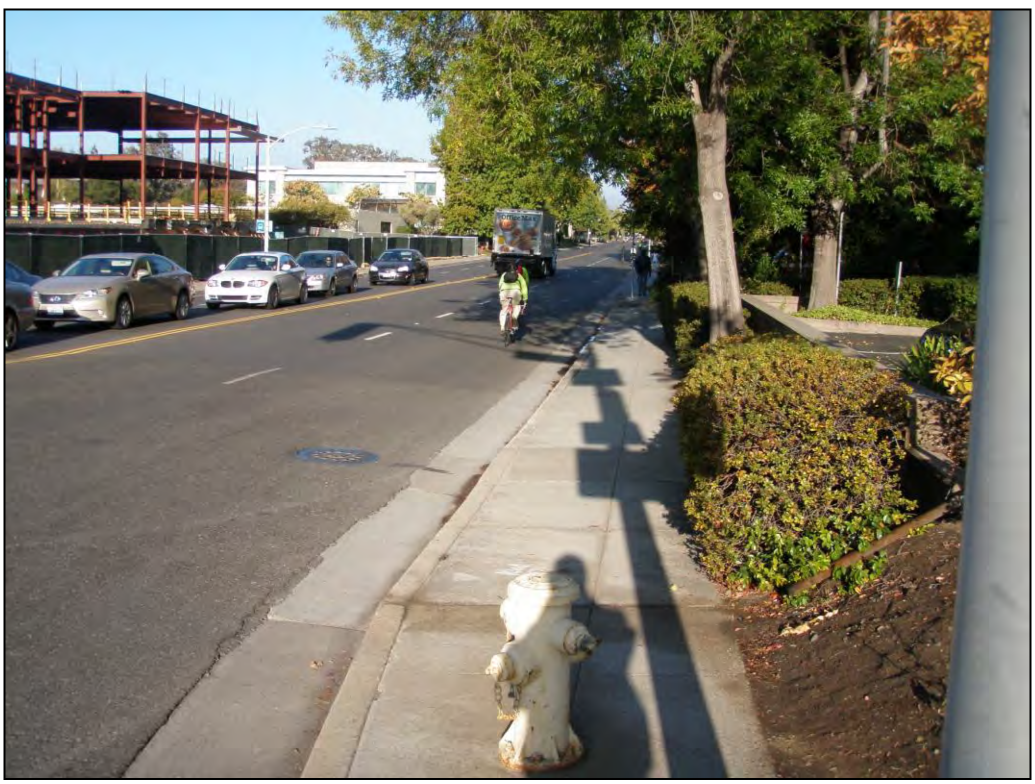

Photo 8: View W along Hanover toward the intersection with California Ave.

Photo 9: View E along Porter Drive from Page Mill Rd.

Photo 10: View NE along Arastradero Rd. from Miranda Ave.

Photo 11: View NE along lateral from Deer Creek Drive to Hillview Ave.

Photo 12: View SW along Adobe Creek at the Middlefield Rd. crossing.

Photo 13: View SW along Barron Creek at the Miranda Avenue crossing.

Photo 14: View WE along Middlefield Rd. from East Meadow Drive.

Photo 15: View W along Fabian Way from East Meadow Drive.

Photo 16: View NE along Hansen Way.

Photo 17: View NE along Page Mill Rd. -- proposed booster pump station location (arrow).

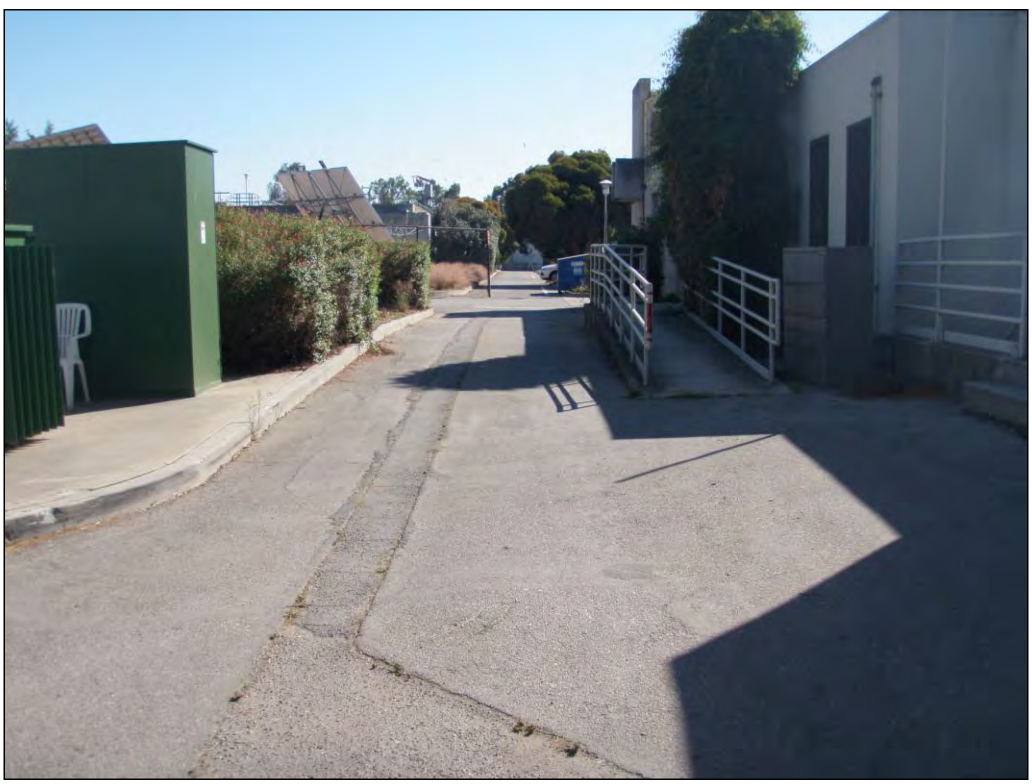

Photo 18: View SE inside the RWQCP at one possible location for tanks.

Photo 19: View SE inside the RWQCP at another possible location for tanks.

Appendix L – Hazardous Materials Database Search Results

ENVIROSTOR SEARCH RESULTS

ENVIROSTOR ID	PROJECT NAME	STATUS	PROJECT TYPE	ADDRESS	CITY
71003431	Communications & Power Ind, Inc.	No Further Action	Corrective Action	607 Hansen Way (Contiguous Pr)	Palo Alto
80001795	HEWLETT-PACKARD	Inactive - Needs Evaluation	Corrective Action	3500 DEER CREEK RD	PALO ALTO
80001599	HEWLETT-PACKARD COMPANY	Refer: RWQCB	Corrective Action	395 PAGE MILL RD	PALO ALTO
80001598	HEWLETT-PACKARD COMPANY	Refer: RWQCB	Corrective Action	1501 PAGE MILL RD	PALO ALTO
80001826	INTEVAC	Refer: RWQCB	Corrective Action	601 CALIFORNIA AVE	PALO ALTO
80001285	SPACE SYSTEMS/LORAL	Refer: RWQCB	Corrective Action	3825 FABIAN WAY	PALO ALTO
80001596	VARIAN NMR SYSTEMS	Refer: SMBRP	Corrective Action	3120 HANSEN WAY	PALO ALTO
43350082	HEWLETT-PACKARD (620-640 PAGE	Refer: RWQCB	Federal Superfund	620-640 PAGE MILL ROAD	PALO ALTO
CAD009124256	AFFYMAX INC	PROTECTIVE FILER	Non-Operating	4001 MIRANDA AVE	PALO ALTO
CAR000003863	COMMUNICATIONS & POWER INDU	CLOSED	Non-Operating	607 HANSEN WAY	PALO ALTO
CAD009122557	HEWLETT-PACKARD COMPANY	CLOSED	Non-Operating	395 PAGE MILL RD	PALO ALTO
CAD009122532	HEWLETT-PACKARD COMPANY	CLOSED	Non-Operating	1501 PAGE MILL RD	PALO ALTO
CAT000617266	HEWLETT-PACKARD COMPANY	CLOSED	Non-Operating	3500 DEER CREEK RD	PALO ALTO
CAT080010804	INTEVAC	CLOSED	Non-Operating	601 CALIFORNIA AVE	PALO ALTO
CAD009129354	LOCKHEED MARTIN SPACE SYSTEMS	CLOSED	Non-Operating	3251 HANOVER ST	PALO ALTO
CAD000030528	SPACE SYSTEMS/LORAL LLC BUILDIN	CLOSED	Non-Operating	3825 FABIAN WAY	PALO ALTO
CAD009120817	VARIAN MEDICAL SYSTEMS PALO AL	CLOSED	Non-Operating	3120 HANSEN WAY	PALO ALTO
43360085	AYDIN ENERGY	Certified / Operation & Maintenance	State Response	3180 HANOVER STREET	PALO ALTO
43360078	HEWLETT PACKARD BUILDING 15	Certified / Operation & Maintenance	State Response	3215 PORTER DRIVE	PALO ALTO
43350089	HEWLETT PACKARD BUILDINGS 28A	Certified / Operation & Maintenance	State Response	CORNER OF PAGE MILL RD AND PORTER DRIVE	PALO ALTO
43360077	HILLVIEW PORTER PLUME	Certified / Operation & Maintenance	State Response	HILLVIEW AVENUE AND PORTER DRIVE	PALO ALTO
43280130	LOCKHEED MISSILES AND SPACE CO	Certified / Operation & Maintenance	State Response	3170 PORTER DRIVE	PALO ALTO
43360079	SMITHKLINE AND FRENCH LABORAT	Certified / Operation & Maintenance	State Response	3400 HILLVIEW AVENUE	PALO ALTO
43360114	SYNTEX	Certified / Operation & Maintenance	State Response	3300 HILLVIEW AVE	PALO ALTO
43360088	TELEDYNE MEC	Certified / Operation & Maintenance	State Response	3165 PORTER DR	PALO ALTO
43360073	TELEDYNE SINGER	Certified / Operation & Maintenance	State Response	3176 PORTER DRIVE	PALO ALTO
43360086	VARIAN	Certified / Operation & Maintenance	State Response	611 HANSEN WAY	PALO ALTO
43360076	WATKINS JOHNSON COMPANY (SRP	Certified / Operation & Maintenance	State Response	3333 HILLVIEW AVENUE	PALO ALTO
60002078	COMMUNICATIONS & POWER IND,	No Further Action	Tiered Permit	607 HANSEN WAY (CONTIGUOUS PR)	PALO ALTO
71004116	Dow Jones & Company, Wall Street	Inactive - Needs Evaluation	Tiered Permit	1701 Page Mill Road	Palo Alto
71003446	DPIX, LLC	Inactive - Needs Evaluation	Tiered Permit	3406 Hillview Avenue	Palo Alto
71002581	Hewlett Packard Co. - Calif. Ave., Pa	Inactive - Needs Evaluation	Tiered Permit	1601 California Avenue	Palo Alto
71002260	Hewlett-Packard Co. - Palo Alto Fab	Inactive - Needs Evaluation	Tiered Permit	395 Page Mill Road	Palo Alto
71003497	Hewlett-Packard Labs - Deer Crk, Pa	Refer: Other Agency	Tiered Permit	3500 Deer Creek Road	Palo Alto
71002259	Hewlett-Packard Labs - Page Mill, Pa	Refer: Other Agency	Tiered Permit	1501 Page Mill Road	Palo Alto
71002282	Roche Bioscience	Inactive - Needs Evaluation	Tiered Permit	3401 Hillview Avenue	Palo Alto
71002502	Watkin's-Johnson Co. - Palo Alto	Inactive - Needs Evaluation	Tiered Permit	3333 Hillview Avenue	Palo Alto
71002578	Xerox Corp., Palo Alto Research Cen	Inactive - Needs Evaluation	Tiered Permit	3333 Coyote Hill Road	Palo Alto
60001911	California Avenue Housing Phase II S	No Further Action	Voluntary Cleanup	1501 California Avenue	Palo Alto
60001837	California Avenue Housing Site	No Further Action	Voluntary Cleanup	1451-1481 California Avenue	Palo Alto

GEOTRACKER SEARCH RESULTS

SITE NAME	GLOBAL ID	STATUS	ADDRESS	CITY
ALTA MESA MEMORIAL PARK	T0608500126	COMPLETED - CASE CLOSED	695 ARASTRADERO RD	PALO ALTO
ALZA BUILDING D	SL1825E1228	COMPLETED - CASE CLOSED	2575 HANOVER ST	PALO ALTO
ALZA CORP	SL18296717	COMPLETED - CASE CLOSED	1454 PAGE MILL RD	PALO ALTO
BECKMAN INSTRUMENTS	SL0608587795	COMPLETED - CASE CLOSED	1050 PAGE MILL RD	PALO ALTO
BLEIBLER IRON WORKS	T0608501747	COMPLETED - CASE CLOSED	411 PAGE MILL RD	PALO ALTO
CHEVRON	T0608500394	COMPLETED - CASE CLOSED	775 PAGE MILL RD	PALO ALTO
CONSOLIDATED FREIGHTWAYS	T0608500455	COMPLETED - CASE CLOSED	3240 HILLVIEW AVE	PALO ALTO
DOW JONES	T0608500528	COMPLETED - CASE CLOSED	1701 PAGE MILL RD	PALO ALTO
DOW JONES	T0608502347	COMPLETED - CASE CLOSED	1701 PAGE MILL RD	PALO ALTO
DPIX LLC	T10000002637	COMPLETED - CASE CLOSED	3406 HILLVIEW AVENUE	PALO ALTO
GAVENMAN PROPERTY	T0608548811	COMPLETED - CASE CLOSED	3017 EL CAMINO REAL	PALO ALTO
GREEN WORLD NURSERY	T0608501659	COMPLETED - CASE CLOSED	2711 EL CAMINO REAL	PALO ALTO
HEWLETT PACKARD	T0608501755	COMPLETED - CASE CLOSED	3500 DEER CREEK RD	PALO ALTO
HEWLETT PACKARD	T0608568601	COMPLETED - CASE CLOSED	3500 DEER CREEK RD	PALO ALTO
HEWLETT-PACKARD	T0608502399	COMPLETED - CASE CLOSED	395 PAGE MILL RD	PALO ALTO
LOCKHEED MARTIN SPACE SYSTEMS	SL0608524762	COMPLETED - CASE CLOSED	3170 PORTER DRIVE	PALO ALTO
LOCKHEED MISSILES	T0608501683	COMPLETED - CASE CLOSED	3251 HANOVER ST	PALO ALTO
MERCER PROCESSING	SL0608568096	COMPLETED - CASE CLOSED	230 PORTAGE AVE	PALO ALTO
MOBIL (BP 11219)	T0608500216	COMPLETED - CASE CLOSED	2780 EL CAMINO REAL	PALO ALTO
MOZART PROPERTY	T0608501013	COMPLETED - CASE CLOSED	1068 MEADOW CIR E	PALO ALTO
PALO ALTO FIRE STATION #2	T0608561135	COMPLETED - CASE CLOSED	2675 HANOVER ST.	PALO ALTO
PALO ALTO NISSAN	T0608555022	COMPLETED - CASE CLOSED	3001 EL CAMINO REAL	PALO ALTO
SHELL	T0608501294	COMPLETED - CASE CLOSED	3900 MIDDLEFIELD RD	PALO ALTO
V.A. MEDICAL CENTER	T0608501758	COMPLETED - CASE CLOSED	3801 MIRANDA AVE	PALO ALTO
VANCE BROWN & SONS	T0608501823	COMPLETED - CASE CLOSED	2747 PARK BLVD	PALO ALTO
VANCE BROWN & SONS	T0608501727	COMPLETED - CASE CLOSED	3101 PARK BLVD	PALO ALTO
STANFORD CLEANERS	T0608591612	COMPLETED - CASE CLOSED - LAND USE RESTRIC	2875 EL CAMINO REAL	PALO ALTO
ESSEX PARK TRUST	T10000005839	OPEN - ASSESSMENT & INTERIM REMEDIAL ACTI	2785-2787 PARK BOULEVARD	PALO ALTO
EASTMAN KODAK COMPANY	T0608591791	OPEN - INACTIVE	925 PAGE MILL RD	PALO ALTO
WATKINS JOHNSON COMPANY	T0608591625	OPEN - INACTIVE	3333 HILLVIEW AVE	PALO ALTO
3400 HILLVIEW AVENUE SITE [NPDES]	SL0608563745	OPEN - REMEDIATION	3400 HILLVIEW AVE.	PALO ALTO
BECKMAN COULTER	T10000001712	OPEN - REMEDIATION	1050 PAGE MILL ROAD	PALO ALTO
FORMER COHERENT INC. FACILITY	SL0608552838	OPEN - REMEDIATION	3210 PORTER DRIVE	PALO ALTO
FORMER FORD AEROSPACE	SL18288709	OPEN - REMEDIATION	3825 FABIAN WY	PALO ALTO
HEWLETT- PACKARD COMPANY	SL18297718	OPEN - REMEDIATION	3500 DEER CREEK RD	PALO ALTO
HEWLETT-PACKARD COMPANY BUILDING 15 SIT	SL0608567552	OPEN - REMEDIATION	3215 PORTER DRIVE	PALO ALTO
HILLVIEW PORTER REGIONAL PROGRAM [NPDE	SL0608548639	OPEN - REMEDIATION	3215 PORTER DRIVE	PALO ALTO
HOHBACH	T0608500732	OPEN - REMEDIATION	200 PAGE MILL	PALO ALTO
JAY PAUL REDEVELOPMENT	T10000005459	OPEN - REMEDIATION	395 / 3045 PAGE MILL ROAD / PARK	PALO ALTO
OREGON EXPRESSWAY UNDERPASS	SL0608561372	OPEN - REMEDIATION	ALMA STREET	PALO ALTO
POLLACK LLC	T10000005467	OPEN - REMEDIATION	2755 EL CAMINO REAL	PALO ALTO

TELEDYNE-SINGER SITE [NPDES]	SL0608518462	OPEN - REMEDIATION	3176 PORTER DRIVE	PALO ALTO
FAIRCHILD SEMICONDUCTOR SITE	SL18220618	OPEN - REMEDIATION - LAND USE RESTRICTIONS	4001 MIRANDA AVE	PALO ALTO
HEWLETT PACKARD COMPANY	SL18321741	OPEN - REMEDIATION - LAND USE RESTRICTIONS	395 PAGE MILL RD	PALO ALTO
HEWLETT-PACKARD COMPANY	SL720501209	OPEN - REMEDIATION - LAND USE RESTRICTIONS	1501 PAGE MILL RD	PALO ALTO
HEWLETT-PACKARD COMPANY	SL720511210	OPEN - REMEDIATION - LAND USE RESTRICTIONS	640 PAGE MILL RD	PALO ALTO
HEWLETT-PACKARD COMPANY	SL720501209	OPEN - REMEDIATION - LAND USE RESTRICTIONS	1501 PAGE MILL RD	PALO ALTO
PROPOSED PARK PLAZA APARTMENTS	T0608572772	OPEN - SITE ASSESSMENT	2785 PARK BOULEVARD	PALO ALTO
VARIAN ASSOCIATES	SL181201123	OPEN - VERIFICATION MONITORING - LAND USE	601 S. CALIFORNIA AVE.	PALO ALTO

Hazardous Waste and Substances Site List

SITE / FACILITY NAME	ENVIROSTOR ID	PROGRAM TYPE	STATUS	STATUS DATE	ADDRESS DESCRIPTION	CITY	ZIP	COUNTY	SITE CODE	LATITUDE	LONGITUDE
AYDIN ENERGY	43360085	STATE RESPONSE	CERTIFIED / OPERATIO	9/30/1997	3180 HANOVER STREET	PALO ALTO	94304	SANTA CLARA	200010	37.41465	-122.146
COHERENT INC	43360115	STATE RESPONSE	CERTIFIED / OPERATIO	7/11/1996	3210 PORTER DR	PALO ALTO	94304	SANTA CLARA	200138	37.40725	-122.147
HEWLETT PACKARD BUILDING 15	43360078	STATE RESPONSE	CERTIFIED / OPERATIO	7/31/1995	3215 PORTER DRIVE	PALO ALTO	94304	SANTA CLARA	200119	37.40898	-122.148
HEWLETT PACKARD BUILDINGS 28A, B, AND C	43350089	STATE RESPONSE	CERTIFIED / OPERATIO	6/30/1995	CORNER OF PAGE MILL RD AND	PALO ALTO	94304	SANTA CLARA	200142	37.40971	-122.152
HILLVIEW PORTER PLUME	43360077	STATE RESPONSE	CERTIFIED / OPERATIO	6/30/1997	HILLVIEW AVENUE AND PORTER	PALO ALTO	94304	SANTA CLARA	200048	37.40778	-122.15
LOCKHEED MISSILES AND SPACE CO BLDG 255	43280130	STATE RESPONSE	CERTIFIED / OPERATIO	4/30/1997	3170 PORTER DRIVE	PALO ALTO	94304	SANTA CLARA	200139	37.4069	-122.152
SMITHKLINE AND FRENCH LABORATORIES	43360079	STATE RESPONSE	CERTIFIED / OPERATIO	4/29/1996	3400 HILLVIEW AVENUE	PALO ALTO	94304	SANTA CLARA	200118	37.40406	-122.149
SYNTEX	43360114	STATE RESPONSE	CERTIFIED / OPERATIO	5/28/1996	3300 HILLVIEW AVE	PALO ALTO	94304	SANTA CLARA	200141	37.40688	-122.146
TELEDYNE MEC	43360088	STATE RESPONSE	CERTIFIED / OPERATIO	9/12/1995	3165 PORTER DR	PALO ALTO	94304	SANTA CLARA	200140	37.40902	-122.15
TELEDYNE SINGER	43360073	STATE RESPONSE	CERTIFIED / OPERATIO	7/31/1995	3176 PORTER DRIVE	PALO ALTO	94304	SANTA CLARA	200096	37.40684	-122.149
VARIAN	43360086	STATE RESPONSE	CERTIFIED / OPERATIO	8/21/1997	611 HANSEN WAY	PALO ALTO	94304	SANTA CLARA	200122	37.41999	-122.137
WATKINS JOHNSON COMPANY (SRP)	43360076	STATE RESPONSE	CERTIFIED / OPERATIO	8/30/1996	3333 HILLVIEW AVENUE	PALO ALTO	94304	SANTA CLARA	200137	37.40809	-122.143

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Appendix M – City of Palo Resolutions 9449 and 9460

Resolution No. 9449

Resolution of the Council of the City of Palo Alto Implementing Outdoor Water Use Restrictions in Compliance with the State Water Resources Control Board's July 15, 2014 Emergency Drought Regulations

RECITALS

A. On January 17, 2014, Governor Edmund G. Brown Jr. issued Proclamation No. 1-17-2014 declaring a State of Emergency to exist in California due to severe drought conditions and calling on Californians to reduce their water usage by 20 percent.

B. On April 25, 2014, the Governor issued an Executive Order to strengthen the state's ability to manage water and directed the State Water Resources Control Board (SWRCB) under its authority in California Water Code Section 1058.5 to adopt emergency regulations as it deems necessary to address water shortage conditions.

C. On July 15, 2014, the State Water Resources Control Board adopted California Code of Regulations, Title 23, Sections 863, 864, and 865, emergency regulations finding a drought emergency in California and imposing water conservation measures on individuals and water suppliers.

D. Section 864 applies to all Californians and prohibits certain activities in promotion of water conservation, many of which are already required by Palo Alto Municipal Code 12.32.010.

E. Section 865 requires mandatory outdoor irrigation restrictions and reporting by water suppliers, including urban water suppliers like the City of Palo Alto.

F. The City of Palo Alto receives 100% of its potable supplies from the San Francisco Public Utilities Commission (SFPUC).

G. The SFPUC has requested a 10% voluntary water consumption reduction in response to the drought and their determination of available supplies in the regional water system.

H. The SFPUC has not declared a water shortage emergency nor imposed mandatory cutbacks upon Palo Alto or any of SFPUC's wholesale customers.

I. The City of Palo Alto has responded to SFPUC's voluntary water consumption reduction request and has achieved an approximate 17% reduction in water use relative to 2013.

J. The City's Municipal Code and Urban Water Management Plan (approved by the City Council on June 13, 2011) include a Water Shortage Contingency Plan and other tools to encourage responsible management of the City's water resources.

K. The City supports the SWRCB's efforts to encourage conservation, with an emphasis on outdoor water use, to the extent it may do so within the context of its Council-approved Urban Water Management Plan and the Palo Alto Municipal Code.

The Council of the City of Palo Alto RESOLVES as follows:

SECTION 1. The following outdoor water use restrictions are hereby adopted, in compliance with the State Water Resources Control Board's July 15, 2014 emergency drought regulations (collectively, the "Outdoor Water Use Restrictions"):

a. No outdoor irrigation of ornamental landscapes or turf with potable water is permitted between the hours of 10am and 6pm, except for drip irrigation, soaker hoses and hand watering;
b. The application of potable water to driveways and sidewalks is prohibited, except where necessary to address an immediate health and safety need or to comply with a term or condition in a permit issued by a state or federal agency; and
c. The use of potable water in a fountain or other decorative water feature is prohibited, except where the water is part of a recirculating system.

SECTION 2. The Council finds that the Outdoor Water Use Restrictions implemented as a result of this action were taken from Stage II of the City's Water Shortage Contingency Plan, which is itself a part of the City's Urban Water Management Plan, approved by the Department of Water Resources July 8th, 2014. The Outdoor Water Use Restrictions are intended to complement the City's existing and permanent water use restrictions, codified in Palo Alto Municipal Code Section 12.32.010.

SECTION 3. The Council finds that adoption of the Outdoor Water Use Restrictions meets the requirements of California Code of Regulations, Title 23, Section 865(b)(1).

SECTION 4. The Outdoor Water Use Restrictions will remain in effect for the 270 day period specified in SWRCB Resolution No. 2014-0038, or as extended by the SWRCB.

SECTION 5. Council directs staff to further promote water conservation by preparing and submitting to the SWRCB the monitoring reports described in California Code of Regulations, Title 23, Section 865(d). Council also directs staff to monitor compliance and to explore increased enforcement in the event the desired response is not being achieved.

SECTION 6. Council's adoption of the proposed Outdoor Water Use Restrictions is categorically exempt from CEQA under CEQA Guidelines 15307 (Actions by Regulatory Agencies for Protection of Natural Resources).

INTRODUCED AND PASSED: August 4, 2014

AYES: BERMAN, BURT, HOLMAN, KLEIN, KNISS, PRICE, SCHARFF, SCHMID, SHEPHERD

NOES:

ABSENT:

ABSTENTIONS:

ATTEST:

for City Clerk

Mayor

APPROVED AS TO FORM:

Senior Deputy City Attorney

APPROVED:

City Manager

Director of Utilities

Director of Administrative Services

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Resolution No. 9460

Resolution of the Council of the City of Palo Alto Establishing the Enforcement Process For Violations of the Three Outdoor Water Use Restrictions Adopted by Council on August 4, 2014 (Resolution 9449)

RECITALS

A. On January 17, 2014, Governor Edmund G. Brown Jr. issued Proclamation No. 1-17-2014 declaring a State of Emergency to exist in California due to severe drought conditions and calling on Californians to reduce their water usage by 20 percent.

B. On April 25, 2014, the Governor issued an Executive Order to strengthen the state's ability to manage water and directed the State Water Resources Control Board (SWRCB) under its authority in California Water Code Section 1058.5 to adopt emergency regulations as it deems necessary to address water shortage conditions.

C. On July 15, 2014, the State Water Resources Control Board adopted California Code of Regulations, Title 23, Sections 863, 864, and 865, emergency regulations finding a drought emergency in California and imposing water conservation measures on individuals and water suppliers.

D. On August 4, the City Council adopted Resolution 9449, implementing outdoor water use restrictions in compliance with the SWRCB emergency directive.

E. The City has implemented an education-based compliance plan and is working with customers to fully comply with the SWRCB water use restrictions.

F. Chapter 12 of City's Municipal Code, City Utilities Rule and Regulation 21, and the Council-approved Urban Water Management Plan include a variety of tools to encourage responsible management of the City's water resources.

G. Violations of the City's water use restrictions codified in Chapter 12.32 of the Palo Alto Municipal Code, are enforceable as misdemeanors, infractions, administrative penalties, or via the written warning and flow restrictor process outlined in Municipal Code Section 12.32.020(a) through (f).

H. Violations of the City's Utilities Rules and Regulations prohibiting water waste, codified in Rule and Regulation 21, are also enforceable via administrative citations of $500 per day.

I. Violations of the State's emergency water use regulations are enforceable by fines of up to $500 per day, under California Code of Regulations, Title 23, Section 864(b).

J. The City wishes to establish an enforcement procedure for violations of the three water use restrictions adopted by Resolution 9449 (Exhibit A), by directing staff to first attempt to achieve compliance via educational outreach, followed by the issuance of fines of $100 per violation per day for willful or repeated violations.

The Council of the City of Palo Alto RESOLVES as follows:

SECTION 1. Findings:

A. Article 10, Section 2 of the California Constitution declares that waters of the State are to be put to beneficial use, that waste, unreasonable use, or unreasonable method of use of water be prevented, and that water be conserved for the public welfare.

B. Governor Brown issued emergency water shortage declarations on January 17 and April 25, 2014, and conservation of current water supplies and minimization of the effects of water supply shortages that are the result of drought are essential to the public health, safety and welfare.

C. City regulation of the time and manner of certain water use, design of rates, method of application of water for certain uses, and establishment of enforcement procedures for violations of water use restrictions are an effective and immediately available means of conserving water, and is authorized by Palo Alto Municipal Code Section 12.20.010.

SECTION 2. Violations of the following Council-adopted outdoor water use restrictions (Resolution 9449) are punishable by fines of $100 per violation:

a. No outdoor irrigation of ornamental landscapes or turf with potable water is permitted between the hours of 10am and 6pm, except for drip irrigation, soaker hoses and hand watering;
b. The application of potable water to driveways and sidewalks is prohibited, except where necessary to address an immediate health and safety need or to comply with a term and condition in a permit issued by a state or federal agency; and
c. The use of potable water in a fountain or other decorative water feature is prohibited, except where the water is part of a recirculating system.

SECTION 3. Each day that a violation of the outdoor water use restrictions described in Section 2 occurs is a separate offense.

SECTION 4. Utilities Department staff shall take primary responsibility for enforcement of the outdoor water use restrictions adopted by Resolution 9449 and described in Section 2, above.

SECTION 5. While nothing in this resolution is intended to limit or otherwise restrict the potential application of all available civil and criminal penalties for violations of the state and local water use restrictions described herein, Council recognizes the value of an education-based approach in encouraging water conservation. Therefore, Council directs staff to first attempt to achieve compliance by providing customers reasonable notice of the alleged violation and an opportunity to correct the problem, before issuing fines for willful and repeated violations.

SECTION 6. If fines are ultimately imposed, the person or persons to whom notice was provided shall have five business days from the date of service of the notice to request a hearing before the city manager or his/her designee in order to present any facts or arguments they may have as to why fines should not be imposed. If a hearing is requested, the city manager or his/her designee shall schedule a date and time for said hearing as soon as possible after the request is filed, but not later than five business days after the filing of such request for hearing. At the hearing, the person who received notice of the water use restriction violation may offer evidence as to why a fine should not be imposed. Utilities personnel shall be allowed to offer whatever evidence they may have as to why the fine should be imposed. The city manager or his/her designee shall make a final determination as to whether or not a fine shall be imposed.

SECTION 7. This resolution will go into effect immediately and will remain in effect for the 270 day term set by the State Water Resources Control Board for the SWRCB's July 15, 2014 emergency water regulations, as extended by the SWRCB, or as directed by Council.

SECTION 8. Council's adoption of the proposed Outdoor Water Use Restrictions is categorically exempt from CEQA under CEQA Guidelines 15307 (Actions by Regulatory Agencies for Protection of Natural Resources).

INTRODUCED AND PASSED: September 15, 2014

AYES: BERMAN, BURT, HOLMAN, KLEIN, KNISS, PRICE, SCHARFF, SCHMID, SHEPHERD

NOES:

ABSENT:

ABSTENTIONS:

ATTEST:

City Clerk

Mayor

APPROVED AS TO FORM:

Senior Deputy City Attorney

APPROVED:

City Manager

Director of Utilities

Director of Administrative Services

Resolution No. 9449

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NOES:

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ABSTENTIONS:

ATTEST:

for City Clerk

Mayor

APPROVED AS TO FORM:

Senior Deputy City Attorney

APPROVED:

City Manager

Director of Utilities

Director of Administrative Services

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