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2-23-0862 (VISTA GRANDE DRAINAGE IMPROVEMENTS)

June 13, 2024

EXHIBITS, PART 3

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VISTA GRANDE DRAINAGE BASIN IMPROVEMENT PROJECT

Mitigation Approach Plan for California Coastal Commission

Prepared for
City of Daly City

November 2022

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VISTA GRANDE DRAINAGE BASIN IMPROVEMENT PROJECT

Mitigation Approach Plan for California Coastal Commission

Prepared for
City of Daly City

November 2022

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SECTION 1
Introduction

1.1 Introduction

This Mitigation Approach Plan (Plan) was prepared for the City of Daly City's (City) Vista Grande Drainage Basin Improvement Project (Project). This Plan provides details for restoring and revegetating project areas under jurisdiction of the California Coastal Commission (CCC or Commission) that are anticipated to be impacted by the Project. This Plan also provides details regarding the fulfillment of compensatory mitigation for permanent Project impacts resulting from construction. This Plan has been prepared pursuant to the mitigation requirements of the Project's Final Environmental Impact Report/Environmental Impact Statement (EIR/EIS). The Project construction impacts (temporary and permanent) to Lake Merced open waters, freshwater marsh wetlands (California bulrush marsh and smartweed - cocklebur patches), arroyo willow riparian areas, and the riparian banks of the Vista Grande Canal, and the approach to restoration or compensatory mitigation fulfillment presented herein, are consistent with those addressed in the Project's approved *Riparian and Wetland Restoration and Mitigation Monitoring Plan for the San Francisco Regional Water Quality Control Board Jurisdictional Resources* (RWRMMP; ESA, 2022b). This Plan has adapted and expanded upon the RWRMMP to address additional resources regulated by the Coastal Commission that are beyond the jurisdiction of the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) as waters of the State. This Plan also categorizes Project impacts as temporary, long-term temporary and permanent, consistent with guidance from the Commission (Garske-Garcia, 2020).

The Project is a multi-benefit project aimed at providing flood protection, water quality improvements, beneficial reuse of stormwater, and related improvements to public access and recreation. Because the Project seeks to rehabilitate and restore function to the existing overflow siphon and restore water supplies to Lake Merced, restoration of lake levels is not expected to cause any change in the intensity of use of water, or of access thereto. Further, the environmental quality goals of the Project are entirely consistent with San Francisco's Local Coastal Program for preserving recreational and habitat values of Lake Merced.

Given that the Project is a multi-benefit restoration project, the following approach has been used to evaluate the extent of required compensatory mitigation for impacts to waters of the State, and has been accepted by the SFRWQCB. According to the RWQCB's guidance on Wetland Projects and Riparian Repair and Maintenance Projects (applicable to Water Quality Certification and Waste Discharge Requirements [WDR] applications submitted prior to May 28, 2020), compensatory mitigation is not warranted for multi-benefit restoration projects because although a restoration project may adversely impact some existing wetlands and/or riparian areas, ultimately the restoration will produce more and/or better water quality and wetland functions. (*See* San Francisco Bay Regional Water Quality Control Board, *Fact Sheet for Reviewing Wetland and Riparian Projects*, p. 11 [Dec. 1, 2006].) Based on the above guidance, a conceptual mitigation proposal was included in the Project's 401 Certification/WDR application materials submitted to the RWQCB in May 2020 (Application). The proposal concluded the Project is self-mitigating because it includes restoration, re-establishment, and enhancement activities which are built into the Project's objectives. Specifically, the proposal included:

- the Project's anticipated net creation (or re-establishment[1]) of aquatic habitats (including jurisdictional open waters and wetlands) that will result from the planned long-term restoration and management of water surface elevation (WSE) at Lake Merced;
- the construction of new treatment wetlands (to remain non-jurisdictional treatment features, but still provide a range of functions and services that benefit the aquatic resources and the watershed);
- the net removal of in-water structures/fill with the removal and reconstruction of the existing Ocean Outlet structure;
- the enhancement of approximately four (4) acres of coastal dune scrub at Ft. Funston and revegetation of the Canal construction area with native coastal scrub and riparian vegetation that enhances the pre-project patchwork of upland habitats which consist primarily of non-native or invasive alliances; and
- additional/related benefits to aquatic resources and Beneficial Uses, including flood control improvements, water quality improvements, and recreational and public access improvements.

1.2 Project Location

The proposed Project is located in Daly City and in unincorporated Broadmoor Village in northwestern San Mateo County (see **Figure 1-1**). The Vista Grande Drainage Basin is the basin that drains via an underground municipal separate storm sewer system (MS4) that ultimately discharges into the Pacific Ocean via the manmade Vista Grande Canal and underground Vista Grande Tunnel. The Vista Grande Drainage Basin is approximately 2.5 square miles in area and is bordered by San Francisco County to the north, Colma Creek watershed to the south and east, and Thornton State Beach and the Pacific Ocean on the west. As shown in Figure 1-1, the Vista Grande Canal and Tunnel are located primarily within the City and County of San Francisco (San Francisco), with a small portion of the southern end of the Canal located in unincorporated San Mateo County and a construction equipment access route, which would require permanent improvements, at Avalon Canyon located in Daly City. The Canal alignment is adjacent to John Muir Drive and the southwestern shoreline of Lake Merced. The Tunnel runs east to west from the northern end of the Canal beneath private lands, Skyline Boulevard, and Fort Funston, respectively. The Tunnel outlet is located at the Pacific Ocean on the beach west of Fort Funston. Fort Funston is managed by the National Park Service (NPS) as part of the Golden Gate National Recreation Area (GGNRA).

1 Based on historic higher WSEs and the expectation that similar habitats existed with those higher historic WSEs.

SOURCE: McMillen Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 1-1
Location and Jurisdiction

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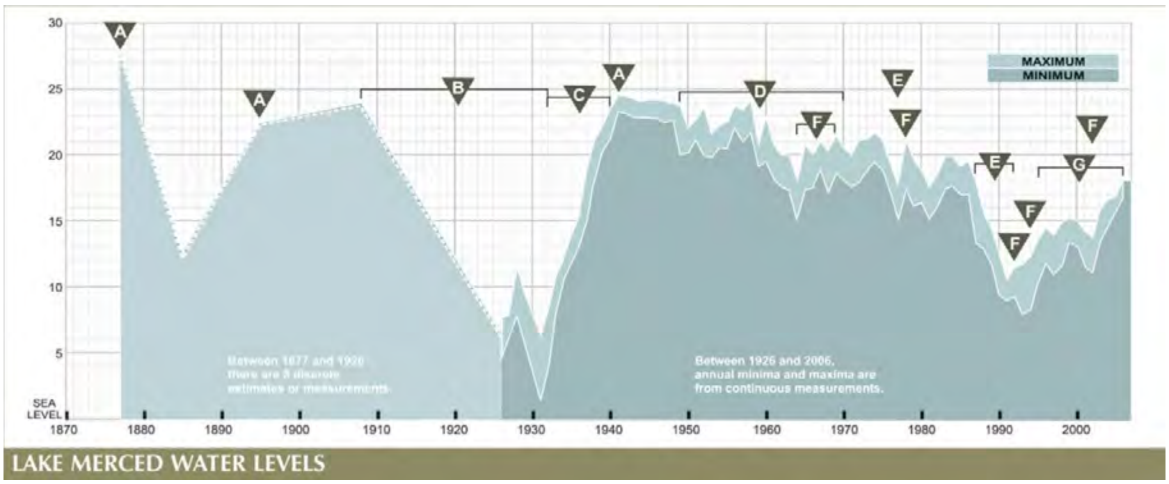
1.3 Historical Baseline Hydrology

Lake Merced is divided into four distinct basins named East Lake, North Lake, South Lake, and Impound Lake (**Figure 1-2**). Of these, South Lake is the largest, measuring 175 acres, followed by North Lake at 58 acres, East Lake at 26 acres, and Impound Lake at 13 acres. Depth also varies among the basins with South Lake at a maximum depth of 22 feet (ft), North and East Lake with maximum depths of 20 ft, and Impound Lake with a maximum depth of 10 ft (SFPUC, 2011). Hydrologically, all four basins are connected (SFPUC, 2011).



NOTES: Legend: A=Lake overflows to the ocean; B=Declines due to groundwater pumping for domestic water use; C=Additions of imported water and curtailing of extractions; D=Increase in groundwater pumping by Daly City; E=Period of drought and high groundwater pumping; F=Additions of imported water; G=Reduction in groundwater pumping and wetter climate period. Y axis denotes WSE in feet above sea level, (i.e., +11 ft relative to San Francisco City Datum). Figure from OMCA (2021).

Figure 1-2
Changes in Lake Merced Water Levels Through Time

Lake Merced is a surface expression of the aquifer system that overlies the Westside Groundwater Basin (Basin) situated below San Francisco. The main sources of freshwater to the lake are precipitation falling on the lake and storm water run-off from the golf courses and the park, conveyed by storm drains and sheet flow. The main water losses from the lake are due to evaporation, plant transpiration, seepage from the lake into the Basin, i.e., groundwater infiltration, and municipal groundwater pumping in the Westside Basin. and water extractions for irrigation and municipal uses.

Extractions of water from the lake and Basin have changed over time and have contributed to the variability in the water level of the lake. Lake elevations (in ft above sea level) typically ranged from 1 to 11 ft (-10 to 0 ft WSE, City Datum), but increased to over 24 ft (13 ft WSE) by the late 1930s (Figure 1-2) after water deliveries from the Hetch Hetchy water system began (Kennedy/Jenks, 2010). After peak water levels were attained in the 1940s, levels were depleted over the next 50 years due to pumping of water for irrigating the golf courses noted above, as well as municipal uses (Figure 1-2). In 1993, water levels reached a minimum of 8 ft above sea level (Figure 1-2), equivalent to -3 ft WSE.

In addition to the water added to the lake described above, the SFPUC started adding water to the lake in the early 2000s. The largest of these additions occurred in 2003, when SFPUC added 705 acre-feet (AF) to the lake (Kennedy/ Jenks, 2010). By 2006, the lake elevation had increased to 14 ft (3 ft WSE).

The Vista Grande Drainage Basin Improvement Project is designed to address localized flooding while also supporting a lake elevation between 17.5 ft and 20.5 ft (6.5 to 9.5 ft WSE). As shown in Figure 1-2, above, these lake levels are within historical baseline levels.

1.4 Project Overview

The overall Project purpose is to provide flood protection for the 25-year/4-hour storm in the lower Vista Grande subbasin, rebuild an existing stormwater outfall in the Pacific Ocean to reduce tidal-zone barriers and permanent fill in jurisdictional waters, while also restoring and managing water elevations in Lake Merced to improve water quality by beneficially reusing stormwater. The proposed Project has two primary, mutually supporting objectives, explained in greater detail below: to address storm-related flooding that periodically occurs as a result of inadequate storm drainage capacity in Daly City's Vista Grande Canal and Tunnel, and to augment water surface levels in San Francisco's Lake Merced for management of both lake volume and water quality. Both Daly City and San Francisco independently are obligated to address these issues. The proposed Project represents an approach that would jointly address both cities' obligations while minimizing disturbance and maximizing the beneficial reuse of stormwater. Two other important objectives of the Project are to improve recreational access and reduce litter transfer and deposition along the beach below Fort Funston by improving the existing Ocean Outlet structure, and to minimize construction-related costs, habitat disturbance, and disruption to recreational users by maximizing use of existing rights-of-way, easements, and infrastructure.

The Project consists of the following components, as shown on Figures 1-3 – 1-6, located at the end of this section:

- Partial replacement of the existing Vista Grande Canal to incorporate a gross solid screening device, a constructed treatment wetland, and diversion and discharge structures (outlet structure in Impound Lake) to route some stormwater (and authorized non-storm water) flows from the Vista Grande Canal to Lake Merced and to allow lake water to be used for summer treatment wetland maintenance, consistent with the Lake Management Plan (LMP);
- Modification of the existing effluent gravity pipeline so that it may be used year-round to convey treated effluent/recycled water from the nearby North San Mateo County Sanitation District waste water treatment plant (WWTP) to the existing outlet and diffuser by gravity, and abandoning the force main pipeline;
- Modification of the elevation and configuration of the existing Lake Merced overflow structure in South Lake to include an overflow siphon that allows water from the Lake to flow passively by gravity into the Canal and Tunnel;
- Replacement of the existing Vista Grande Tunnel to expand its hydraulic capacity and extend its operating lifetime and replacement of the Lake Merced Portal to the Tunnel;

- Replacement of the existing Ocean Outlet structure and a portion of the existing 33-inch submarine outfall pipeline that crosses the beach at Fort Funston; and
- Improvements to the existing Avalon Canyon Access Road to provide construction equipment access to the beach at Fort Funston.

1.5 Responsible Parties

The City of Daly City is responsible for ensuring that this Plan is implemented and that revegetation meets the performance standards outlined in this document.

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153 Lake Merced Boulevard
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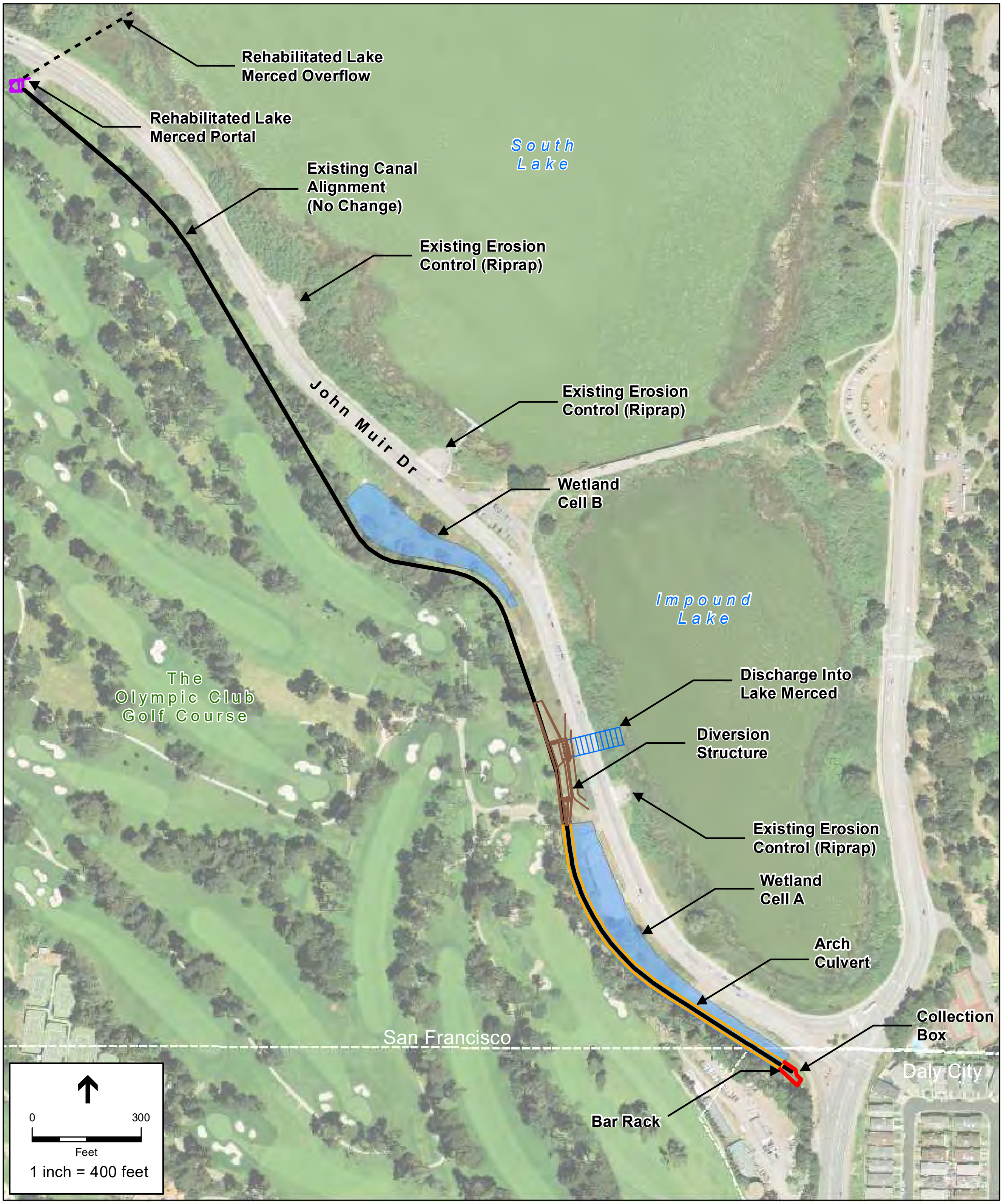
1.6 Plan Components

The Mitigation Approach Plan is organized into the following seven sections.

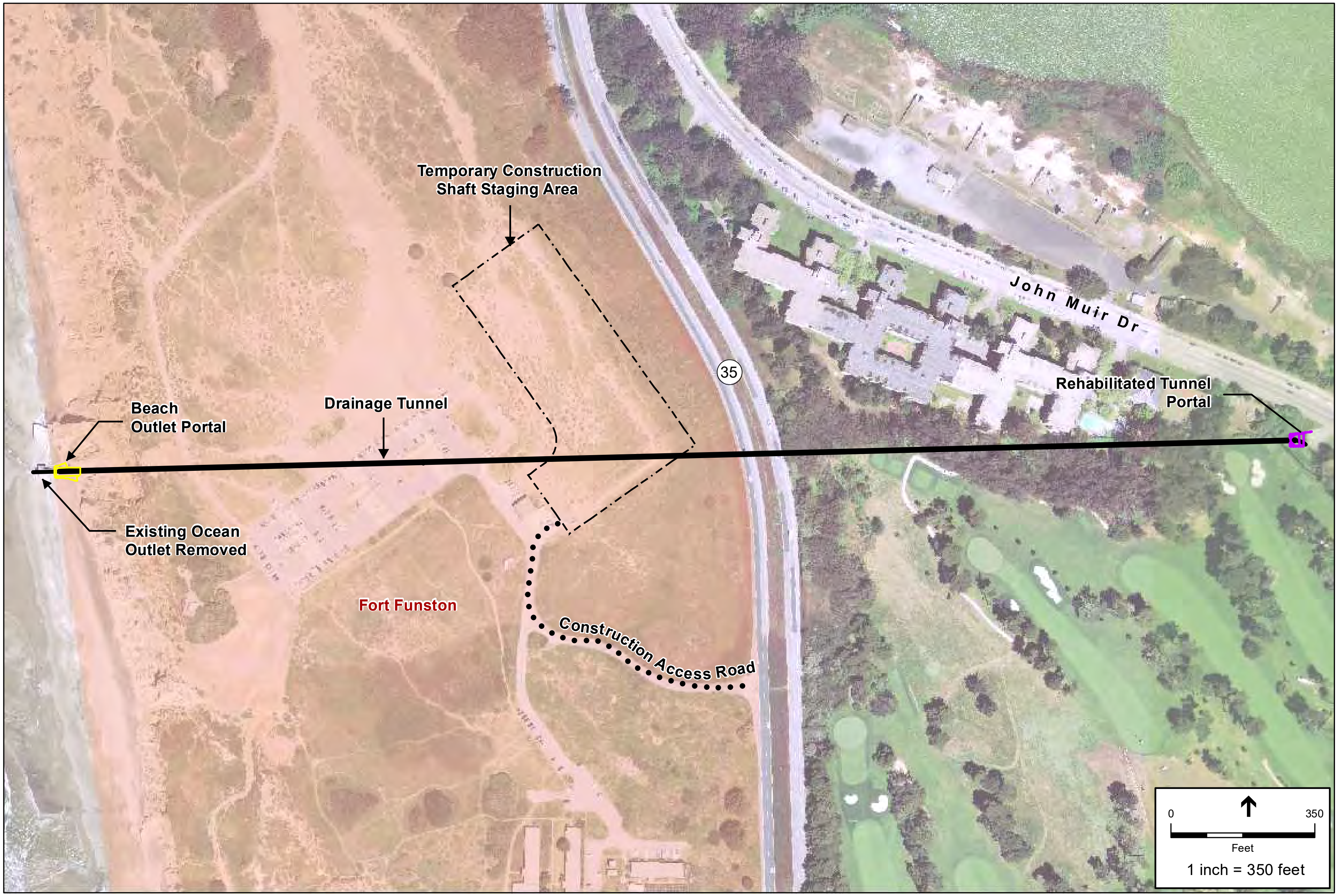
- Section 1, Introduction
- Section 2, Plan Purpose and Goals
- Section 3, Project Impacts and Revegetation Areas
- Section 4, Restoration Methods for Temporarily Disturbed Areas
- Section 5, Monitoring Methods and Reporting
- Section 6, Fulfillment of Compensatory Mitigation for Permanent Impacts: Re-establishment and Enhancement of Wetlands and Open Waters
- Section 7, Plan Preparation and References



SOURCE: McMillen Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 1-3
Proposed Project Components (Canal)



SOURCE: McMillen Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 1-4

Proposed Project Components (Tunnel)

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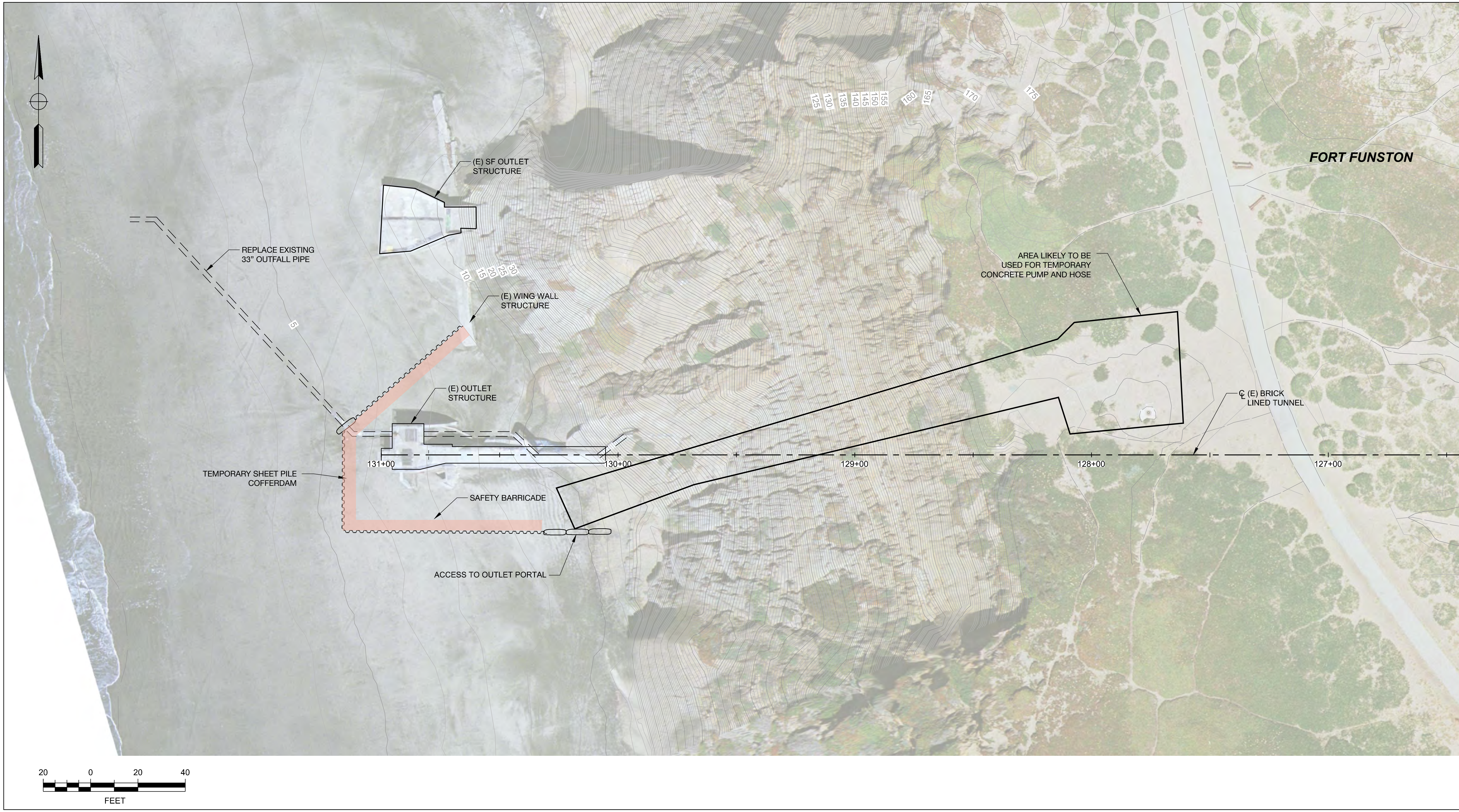


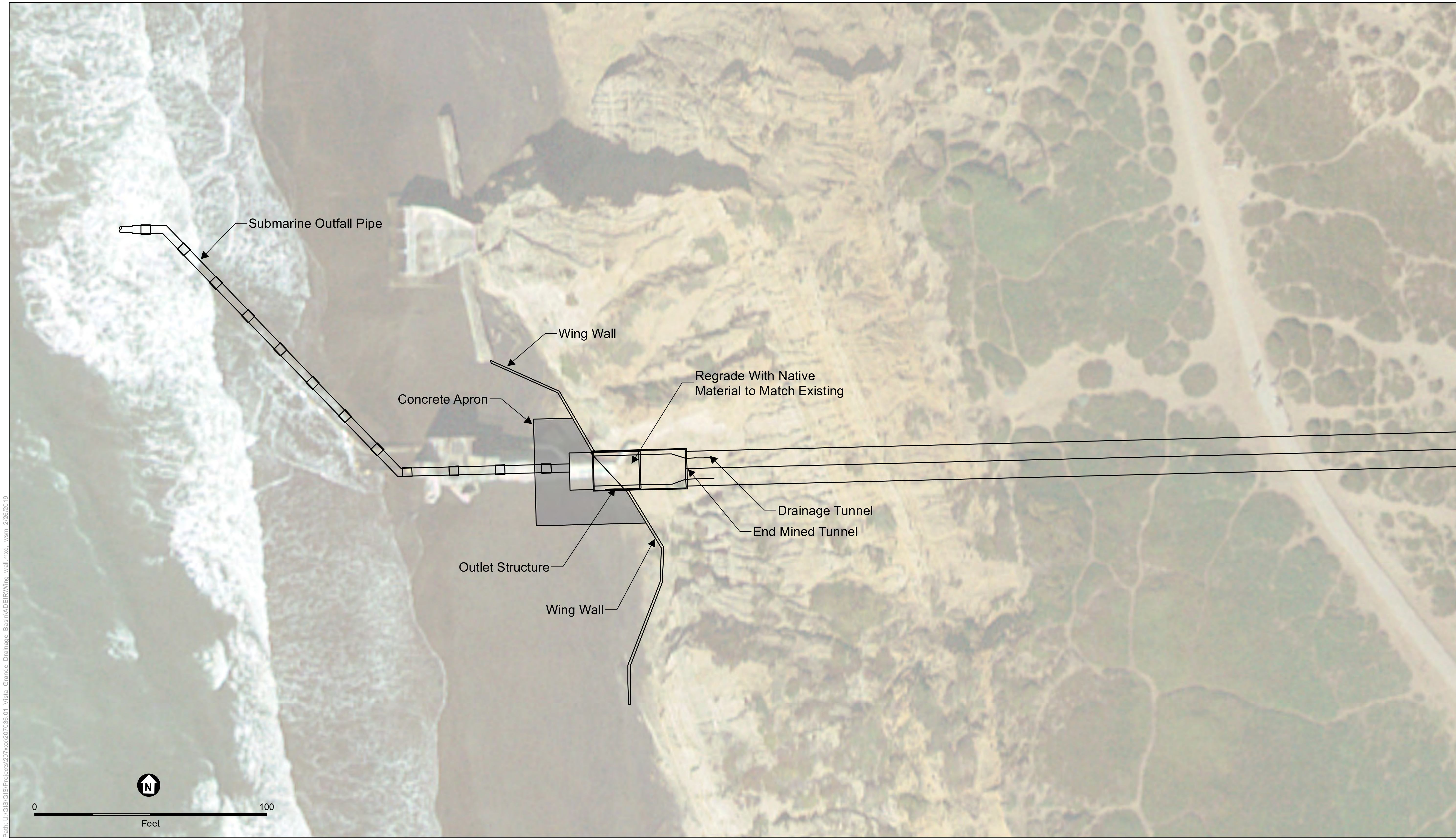
SOURCE: Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project . 207036.01

Figure 1-5a

Ocean Outlet Construction Area

2-23-0862
Exhibit 4



SOURCE: McMillen-Jacobs Associates, 2019

Vista Grande Drainage Basin Improvement Project . 207036.01

Figure 1-5b
Ocean Outlet Structure Final Footprint

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Exhibit 4

Path: U:\GIS\GIS\Projects\207xxx\207036.01 Vista Grande Drainage Basin\Bio\RWQCB 401\Fig 15-4 Avalon Canyon Access rev.mxd, rhaines 6/13/2019

SOURCE:

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 1-6
Avalon Canyon Access Road

ESA

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SECTION 2
Plan Purpose and Goals

2.1 Purpose of the Plan

Project construction will result in temporary,[2] long-term temporary,[3] and permanent[4] impacts on resources within the Project area regulated under the California Coastal Act, including potential environmentally sensitive habitat areas (ESHA) (Garske-Garcia, 2020).[5] The Project will revegetate areas temporarily disturbed during construction of Project infrastructure, such as work areas, staging areas, and access routes.

The purpose of the revegetation actions described herein is to compensate for Project-related construction impacts on resources regulated by the Commission, including the temporal loss of these resources as a part of the Project area ecosystem during construction. The monitoring program that follows will ensure that the implemented onsite restoration mitigation succeeds in compensating for temporary Project construction impacts. Compensatory mitigation for permanent impacts is discussed in Section 6.

Project operation will restore baseline Lake Merced water levels, increasing the water surface elevation (WSE) from approximately 5.7 feet City Datum (baseline conditions) to between 8.0 feet and 9.0 feet City Datum. Because of the shoreline topography of the Lake Merced, raising the lake level is expected to cause changes in shoreline vegetation composition, where different vegetation alliances will expand or contract based on their proximity to the operational waterline and species' tolerance for inundation and saturation. Evolution of the lake's shoreline vegetation in response to increased water levels is not considered to be an operational impact of the Project but rather a restoration of lake and shoreline conditions. Notably, as discussed further

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2 All temporary impacts require that 1) there be no significant ground disturbance, and 2) that vegetation recovers to comparable age classes and/or size structure distributions by the end of the designated period (i.e., short term or long term). Short-term temporary impacts are those where vegetation recovery occurs within 12 months of the initial point of disturbance. Assumes site restoration requirement of 1:1 (acres mitigated : acres impacted).

3 Long-term temporary impacts are those that may be intermittent or sustained for up to a 24-month period such that vegetation recovery may require more than 12 months from the initial point of disturbance but no more than 12 months from the conclusion point of disturbance, thus effectively allowing for as much as 36 months to fully recover. Assumes site restoration requirement of 1.5:1 (acres mitigated : acres impacted), based upon staff report for CDP application 2-20-0281 (Caltrans Gleason Beach Highway 1 Realignment) (Garske-Garcia, 2020).

4 Permanent impacts include areas or key ecological functions that would be lost to development, frequently disturbed in order to maintain development, involve significant ground disturbance, or necessitate more than 12 months for recovery following the conclusion of disturbance. Assumes site restoration requirement of 3:1 (substantial restoration) or 6:1 (enhancement) for upland ESHA and 4:1 (substantial restoration) for wetland ESHA based on guidance received from and correspondence with Commission staff.

5 Note that the Commission has not determined whether ESHA resources are present within the Project area and any reference to potential ESHA within this Plan are based on application of the Coastal Act definition and precedent, and should be considered provisional until a determination is made by the Commission.

in Section 6, the Project is expected to increase herbaceous wetland vegetation (potential ESHA) between 2.04 and 3.41 acres along the Lake Merced shoreline.

2.2 Goals

The goals for the Plan implementation are to:

- Restore habitat functions and integrity by revegetating construction disturbance areas to pre-Project conditions or better (by using observed/documented pre-project site conditions from 2012-2021 as a body of reference, as well as current nearby reference site information);
- Restore and/or substantially enhance dune habitat within Fort Funston (to be coordinated with the National Park Service) to compensate for Project impacts associated with the tunnel staging area.
- Restore and/or substantially enhance coastal scrub habitat within Avalon Canyon to compensate for Project impacts associated with the Avalon Canyon access road improvements.
- Monitor and document Lake Merced shoreline vegetation response to operational lake levels to confirm whether the predicted expansion of herbaceous wetlands satisfactorily compensates for the Project's permanent construction impacts on wetlands (e.g., from placement of new infrastructure).
- Monitor and report on compliance with regulatory agreements and permit conditions; and
- Minimize infestation of the revegetation areas by selected invasive weeds (see Section 4.7).

2.3 Monitoring Program and Performance Standards

The lake's wetland and riparian habitats, Canal riparian banks and adjacent uplands, Fort Funston dunes, and Avalon Canyon coastal scrub that will be restored within the Project site are different from each other in their form, function, establishment characteristics, and habitat qualities. Therefore, this document establishes unique performance standards for the lake's freshwater marsh wetlands (California bulrush and swamp knotweed wetlands), arroyo willow riparian wetlands, the Canal's riparian banks and adjacent uplands, replacement trees, dunes to be revegetated within Fort Funston, and the Avalon Canyon restoration area. All of the performance standards identified herein are based upon the pre-project conditions and cover observed for and documented in the updated Aquatic Resources Delineation (ESA, 2020b; **Appendix A**) and during subsequent field surveys performed by ESA botanists/restoration ecologists. These collective observations conducted between 2012 and 2021 constitute the body of reference for assessment of restoration performance and success. In addition, success will be assessed in comparison to contemporary nearby reference sites established for each of the different impacted habitat types.

Table 2-1 identifies survival, percent cover, and target invasive weed standards for freshwater marsh wetlands. **Table 2-2** identifies these performance standards for arroyo willow riparian wetlands. **Table 2-3** identifies these performance standards for the Canal's riparian corridor and adjacent uplands. The performance standard for replacement trees to be planted within the Canal construction disturbance area is 100 percent survival at the end of the 10-year monitoring period. **Table 2-4** identifies these performance standards for the Fort Funston tunnel staging area and

Ocean Outlet dune restoration areas. **Table 2-5** identifies these performance standards for the Avalon Canyon coastal scrub restoration area. Invasive weeds are prevalent at the Project site in the Canal's construction disturbance area and within Fort Funston, while the lake's freshwater marsh wetland and arroyo willow riparian wetlands are dominated by native species (willows, swamp knotweed, and California bulrush) (see Section 4.7). Maintaining less than 10 percent invasive weed cover in all restoration areas may require diligent invasive weed control in the first years after planting, especially along the Canal.

2.3.1 Lake Merced Wetlands

Performance standards for freshwater marsh and arroyo willow riparian wetlands (as detailed below) are based on the pre-project conditions and cover observed and documented in the updated Aquatic Resources Delineation (ESA, 2020b) and during subsequent field surveys, conducted by ESA botanists/restoration ecologists between 2012 and 2021.

Freshwater Marsh Wetlands

Restored freshwater marsh wetlands will be monitored for at least five years following restoration planting/seeding, or until performance criteria is achieved. The wetland delineation data sheets in the Aquatic Resources Delineation show that total vegetation cover in the freshwater marsh wetlands ranged from 70-100 percent and cover in the willow riparian wetlands ranged from 30 to 75 percent. Subsequent field surveys conducted by ESA botanists/restoration ecologists confirmed these cover ranges. As reflected in Table 2-1, it is reasonable to expect that a minimum cover of 70 percent in freshwater marsh wetlands (i.e., planted and naturally recruited native and non-invasive plant species) will be achieved by the end of the five year monitoring period as this wetland type should establish fairly quickly and colonize the areas with suitable hydrologic conditions. As also shown in Table 2-1, at the end of the five year monitoring period native freshwater marsh plants, including installed plants (California bulrush and swamp knotweed) and other native species that may establish naturally should total at least 50 percent cover. Cattails (*Typha* sp.), sedges (*Carex* sp.) or rush (*Juncus* sp.) taxa are examples of native freshwater marsh plants that will be counted towards the total cover of planted and naturally recruited native freshwater marsh plants.

TABLE 2-1
FRESHWATER MARSH WETLANDS RESTORATION PERFORMANCE STANDARDS

Standard	Year 1	Year 2	Year 3	Year 4	Year 5
Freshwater Marsh (CA bulrush and swamp knotweed wetlands)					
Survival of installed wetland plants (%)	≥70	≥70	n/a	n/a	n/a
Cover of planted and naturally recruited native & non-invasive plant species (%)	n/a	≥30	≥40	≥55	≥70
Cover of planted and naturally recruited native freshwater marsh plants (%)	n/a	n/a	≥25	n/a	≥50
Invasive Weed Cover[1] (%)	≤10	≤10	≤10	≤10	≤10

NOTE:

[1] Invasive weeds are non-native plants considered to be a management priority based on their ecological impacts to plant communities, wildlife habitats, and/or ecosystem functions (see Section 4.7).

Arroyo Willow Wetlands

Arroyo willow riparian wetlands may require up to ten years to establish to its full pre-Project canopy height and density (65 percent cover). Therefore, percent cover in the restored arroyo willow riparian wetland areas will be monitored for ten years with annual performance standards of a positive trend towards greater canopy cover over the monitoring period with a total cover of 65 percent in year ten, as shown in Table 2-2. Cover contributed exclusively by arroyo willow is expected to be at least 25 percent in year five and 50 percent in year ten.

TABLE 2-2
WILLOW RIPARIAN WETLAND RESTORATION PERFORMANCE STANDARDS

Standard	Years 1 and 2	Year 3	Year 4	Year 5	Year 7	Year 10
Survival of installed willow stakes (%)	≥70	n/a	n/a	n/a	n/a	n/a
Cover of arroyo willow and herbaceous understory (%)	n/a	≥25	≥35	≥40	≥50	≥65
Cover of arroyo willow (%)	n/a	≥10	n/a	≥25	n/a	≥50
Invasive Weed Cover[1] (%)	≤10	≤10	≤10	≤10	≤10	≤10

NOTE:
1 Invasive weeds are non-native plants considered to be a management priority based on their ecological impacts to plant communities, wildlife habitats, and/or ecosystem functions (see Section 4.7).

In the first years after planting the most critical measure of success is individual plant establishment, while the measure of total vegetation cover provides a better long-term measure of sucess. For this reason, arroyo willow percent survival will be the primary performance standard for the first and second year after planting while total cover will be used as the primary performance standard beginning in year three to assess habitat restoration performance in arroyo willow riparian wetlands. Another reason for switching the primary performance measure after year two is the difficulty of identifying individuals once plants become established, which greatly complicates a measure of percent survival once plants are established and begin to spread (usually starting in year two).

2.3.2 Canal Riparian Banks and Coastal Scrub Uplands

Performance standards for the Canal's revegetated riparian banks and adjacent uplands, as detailed below, are based on the pre-project conditions and cover observed and documented in the updated Aquatic Resources Delineation (ESA, 2020b) and during subsequent field surveys, as conducted by ESA botanists/restoration ecologists between 2012 and 2021.

Canal riparian bank vegetation and upland vegetation adjacent to the Canal is highly varied in species composition and cover densities depending on what alliance is present. Once construction is complete, temporarily disturbed areas adjacent to the Canal will be hydroseeded with a single native seed mix representative of low-growing shrub and herbaceous native species observed in or typical of local riparian habitat and coastal scrublands (see Section 4.3.2, below).

Performance standards for the Canal's revegetated riparian banks and adjacent uplands are described in Table 2-3 and include the expected growth characteristics of the species included in the seed mix. As shown in the table, monitoring will occur for at least five years, with a target cover of 70 percent by the end of the monitoring period. Because native plants will be establishing from seed, total cover of desirable plants is not expected to be high in the first two years after hydroseeding. By the third year, plants should be well established and cover will increase at a greater rate. The revegetated Canal riparian banks and adjacent uplands will be monitored annually for cover of native species, areas of erosion or slope instability, and presence of invasive weeds.

TABLE 2-3
CANAL RIPARIAN BANKS AND COASTAL SCRUB UPLANDS RESTORATION PERFORMANCE STANDARDS

Standard	Year 1	Year 2	Year 3	Year 4	Year 5
Canal Riparian Banks and Coastal Scrub Uplands					
Cover of seeded and naturally recruited native & non-invasive plant species (%)	n/a	≥30	≥40	≥55	≥70
Invasive Weed Cover[1] (%)	≤10	≤10	≤10	≤10	≤10

NOTE:
1 Invasive weeds are non-native plants considered to be a management priority based on their ecological impacts to plant communities, wildlife habitats, and/or ecosystem functions (see Section 4.7).

2.3.3 Trees

Native trees planted as mitigation for trees removed under the Project will be replaced at a 1:1 ratio. Once construction is complete, and ahead of hydroseeding described in Section 2.3.2., mitigation tree plantings will be installed within the temporarily distubed area between the Canal and John Muir Drive (see Section 4.3.2, below). The performance standard for replacement trees planted within the Canal resotration area is 100 percent survival at the end of the 10-year monitoring period. The Project may elect to plant a greater number of mitigation trees than required to account for some natural loss of plantings to ensure performance by the end of the monitoring period.

2.3.4 Fort Funston Dunes

Performance standards for dune revegetation within Fort Funston (consisting of both revegetation of the tunnel staging area, a portion of the Ocean Outlet construction disturbance area, and the additional compensatory mitigation area) are based on the pre-Project conditions and cover observed and documented during field surveys conducted by ESA botanists/restoration ecologists between 2012 and 2021.

The tunnel staging area consists of large expanses of unvegetated dune sand with sporadic groupings of ice plant mats, with silver dune lupine and mock heather shrubs and other native associates. These conditions are typical of Fort Funston dunes where the public is permitted unrestricted access. Once construction is complete, the temporarily disturbed areas (tunnel staging area and portion of the Ocean Outlet work area near the blufftop) within Fort Funston will be revegetated with native species representative of local native dune species observed or typical of local coastal dunes through a combination of live plantings and seed application (see Section 4.3.2, below).

Performance standards for the Fort Funston dune restoration areas are described in Table 2-4 and include the expected growth characteristics of the species included in the seed mix. Because a majority of native plants will be establishing from seed, total cover of desirable plants is not expected to be very high in the first two years after seeding/planting. By the third year, all plants (introduced from seed or container plantings) should be well established and cover will increase at a greater rate (target of 30 percent cover). The restored dunes will be monitored annually for at least five years to assess and document survival of planted species, cover of native species, and presence of invasive weeds.

TABLE 2-4
FORT FUNSTON DUNES RESTORATION PERFORMANCE STANDARDS

Standard	Year 1	Year 2	Year 3	Year 4	Year 5
Dunes					
Survival of installed dune plants (%)	≥50	≥50	n/a	n/a	n/a
Main Staging Area – Cover of planted/seeded and naturally recruited native & non-invasive plant species (%)	n/a	≥10	≥15	≥20	≥30
Main Staging Area – Invasive Weed Cover[1] (%)	≤10	≤10	≤10	≤10	≤10
Blufftop Staging Area – Cover of planted/seeded and naturally recruited native & non-invasive plant species (%)	n/a	≥10	≥25	≥35	≥50
Blufftop Staging Area – Invasive Weed Cover[1] (%)	<35	<35	<35	<35	<35

NOTE:
1 Invasive weeds are non-native plants considered to be a management priority based on their ecological impacts to plant communities, wildlife habitats, and/or ecosystem functions (see Section 4.7).

2.3.5 Avalon Canyon Coastal Scrub

Performance standards for Avalon Canyon's coastal srub, as detailed below, are based on the pre-project conditions and cover observed and documented in field surveys conducted by ESA botanists/restoration ecologists between 2012 and 2021.

Coastal scrub within Avalon Canyon at the road repair site is dense and dominated by native coastal scrub shrub species. Once construction is complete, the temporarily disturbed area supporting the road repairs (and the additional area required as compensatory mitigation once cleared of existing, non-native vegetation) will be hydroseeded with a single native seed mix representative of native species observed in or typical of local coastal scrub canyons (see Section 4.3.2, below).

Performance standards for Avalon Canyon's coastal scrub are described in Table 2-5 and include the expected growth characteristics of the species included in the seed mix. As shown in the table, monitoring will occur for at least five years, with a target cover of 70 percent by the end of the monitoring period. Because native plants will be establishing from seed, total cover of desirable plants is not expected to be high in the first two years after hydroseeding. By the third year, plants should be well established and cover will increase at a greater rate. The restored Avalon Canyon coastal scrub will be monitored annually for cover of native species and presence of invasive weeds.

TABLE 2-5
AVALON CANYON COASTAL SCRUB RESTORATION PERFORMANCE STANDARDS

Standard	Year 1	Year 2	Year 3	Year 4	Year 5
Avalon Canyon Coastal Scrub					
Cover of seeded and naturally recruited native & non-invasive plant species (%)	n/a	≥30	≥40	≥55	≥70
Invasive Weed Cover[1] (%)	≤10	≤10	≤10	≤10	≤10

NOTE:
1 Invasive weeds are non-native plants considered to be a management priority based on their ecological impacts to plant communities, wildlife habitats, and/or ecosystem functions (see Section 4.7).

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SECTION 3

Project Impacts and Revegetation Areas

3.1 Project Impacts from Construction

3.1.1 Ground Vegetation

Temporary and permanent construction impacts to vegetation alliances within of the Project area are characterized according to duration of disturbance and recovery time of the impacted vegetation alliance to pre-disturbance conditions. **Table 3-1** summarizes the CCC's impact classification methodology, based upon guidance provided by CCC staff following submission of the Project's Coastal Development Permit (CDP) application (Garske-Garcia, 2020).

TABLE 3-1
SUMMARY OF CCC IMPACT CLASSIFICATION SYSTEM

Temporary Impacts
1) No significant ground disturbance; and 2) Vegetation recovers to comparable age classes and/or size structure distributions by the end of the designated period (i.e., short term or long term). – **Short-term Temporary**: vegetation recovery occurs within 12 months of the initial point of disturbance – **Long-term Temporary**: intermittent or sustained impacts for up to a 24-month period such that vegetation recovery may require more than 12 months from the initial point of disturbance but no more than 12 months from the conclusion point of disturbance, thus effectively allowing for as much as 36 months to fully recover.
Permanent Impacts
Areas or key ecological functions that would be lost to development, frequently disturbed in order to maintain development, involve significant ground disturbance, or necessitate more than 12 months for recovery following the conclusion of disturbance.

Appendix B, Figures 1 through 11, depict vegetation alliances mapped within the Project construction disturbance area and classified according to the Manual of California Vegetation (Nomad, 2011; Sawyer et al., 2009). Impact acreage per vegetation alliance is provided for the Project component shown. For Project components which span multiple figures (e.g., the Canal), impact acreage per vegetation alliance is totaled for vegetation polygons within the figure frame. **Table 3-2** presents total impacts to each vegetation alliance within the construction disturbance area, organized by temporary, long-term temporary, and permanent impact categories. Table rows containing alliances identified as potential ESHA are shaded grey. Note that ice plant mats along the Canal have been conservatively identified as potential ESHA based on communication with and guidance from Commission staff pertaining to dunes as categorical ESHA. However, these areas along the Canal mapped as ice plant mats lack other essential dune properties, such as sustained nourishment by aeolian sand transport. Appropriately timed botanical surveys of this

TABLE 3-2
CONSTRUCTION DISTURBANCE IMPACT SUMMARY BY VEGETATION ALLIANCE

Project Component/Location MCV Vegetation Alliance or Habitat Type[a,b]	Construction Footprint Impact (ac) Temporary[c]	Long-term Temporary[d]	Permanent[e]	Compensatory Mitigation Acreage Required beyond Onsite Restoration (Y/N)
Lake Merced – Overflow Structure				
Arroyo willow thicket*+ *Salix lasiolepis Shrubland Alliance*	-	-	0.1279	Y
California bulrush marsh*+ *Schoenoplectus californicus Herbaceous Alliance*	-	0.0231	-	Y
Smartweed – cocklebur patches*+ *Polygonum (=Persicaria) lapathifolium – Xanthium strumarium Herbaceous Alliance*	-	0.0708	-	Y
Himalayan blackberry – rattlebox – edible fig riparian scrub *Rubus armeniacus Semi-Natural Shrubland Stands*	-	0.0222	-	N
Lake Merced – PRGC Staging Area Opt. A				
Arroyo willow thicket*+ *Salix lasiolepis Shrubland Alliance*	-	0.0303	-	Y
Tufted hairgrass meadow+ *Deschampsia cespitosa Herbaceous Alliance*	1.007	-	-	N
Disturbed/Developed	0.0616	-	-	N/A
Lake Merced – PRGC Staging Area Opt. B				
Arroyo willow thicket*+ *Salix lasiolepis Shrubland Alliance*	-	0.0070	-	Y
California bulrush marsh*+ *Schoenoplectus californicus Herbaceous Alliance*	-	0.0110	-	Y
Smartweed – cocklebur patches*+ *Polygonum (=Persicaria) lapathifolium – Xanthium strumarium Herbaceous Alliance*	-	0.0023	-	Y
Tufted hairgrass meadow+ *Deschampsia cespitosa Herbaceous Alliance*	1.0147	-	-	N
Disturbed/Developed	0.0616	-	-	N/A
Lake Merced – Wetland Pump				
Coyote brush scrub *Baccharis pilularis Shrubland Alliance*	0.0133	-	-	N
Disturbed/Developed	0.3556	-	-	N/A
Lake Merced – Outlet Structure				
Arroyo willow thickets*+ *Salix lasiolepis Shrubland Alliance*	-	-	0.1588	Y
California bulrush marsh*+ *Schoenoplectus californicus Herbaceous Alliance*	-	0.0155	0.0129	Y
Smartweed – cocklebur patches*+ *Polygonum (=Persicaria) lapathifolium – Xanthium strumarium Herbaceous Alliance*	-	0.0057	-	Y
Canal				
Arroyo willow thicket*+ *Salix lasiolepis Shrubland Alliance*	-	-	0.0616	Y

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TABLE 3-2 (CONTINUED)
CONSTRUCTION DISTURBANCE IMPACT SUMMARY BY VEGETATION ALLIANCE

Project Component/Location	Construction Footprint Impact (ac)			Compensatory Mitigation Acreage Required beyond Onsite Restoration (Y/N)
MCV Vegetation Alliance or Habitat Type[a,b]	**Temporary[c]**	**Long-term Temporary[d]**	**Permanent[e]**	
Canal (cont.)				
Australian wattle – Grevillea – Tea tree ruderal patches *Acacia spp. – Grevillea spp. – Leptospermum Shrubland Alliance*	-	-	0.1529	N
Bishop pine – Monterey pine forest and woodland *Pinus muricata – Pinus radiata Forest and Woodland Alliance*	-	-	1.1661	N
Coast live oak forest and woodland[+] *Quercus agrifolia Forest and Woodland Alliance*	-	-	0.3692	Y
Coyote brush scrub *Baccharis pilularis Shrubland Alliance*	-	-	0.0678	N
Himalayan blackberry – rattlebox – edible fig riparian scrub *Rubus armeniacus - Sesbania punicea - Ficus carica Shrubland Alliance*	-	0.6501	0.4675	N
Ice plant mats *Mesembryanthemum spp. – Carpobrotus spp. Herbaceous Semi-Natural Alliance*	-	1.0117	0.8902	Y
Pepper tree or Myoporum groves *Schinus [molle, terebinthifolius] – Myoporum laetum Forest and Woodland Semi-Natural Alliance*	-	-	0.2573	N
Poison hemlock or fennel patches *Conium maculatum – Foeniculum vulgare Semi-Natural Alliance*	-	0.4971	0.0443	N
Upland mustards or star-thistle fields *Brassica nigra – Centaurea [solstitialis, melitensis] Herbaceous Semi-Natural Alliance*	-	0.1798	0.0032	N
Wild oats and annual brome grasslands *Avena spp. – Bromus spp. Herbaceous Semi-Natural Alliance*	-	0.203	0.4303	N
Non-native landscaped – Golf Course	-	-	0.4931	N/A
Disturbed/ Developed	0.2502	-	0.2111	N/A
Fort Funston – Tunnel Staging Area				
Silver dune lupine – mock heather scrub[+] *Lupinus chamissonis - Ericameria ericoides Shrubland Alliance*	-	-	1.9262	Y
Ice plant mats *Mesembryanthemum spp. – Carpobrotus spp. Herbaceous Semi-Natural Alliance*	-	-	2.2604	Y
Disturbed/Developed	0.2438	-	-	N/A
Ocean Outlet				
Ice plant mats *Mesembryanthemum spp. – Carpobrotus spp. Herbaceous Semi-Natural Alliance*	-	0.0596	-	Y
Beach	0.2599	-	0.0527	N/A
Disturbed/Barren	0.0501	-	0.0964	N/A

TABLE 3-2 (CONTINUED)
CONSTRUCTION DISTURBANCE IMPACT SUMMARY BY VEGETATION ALLIANCE

Project Component/Location	Construction Footprint Impact (ac)			Compensatory Mitigation Acreage Required beyond Onsite Restoration (Y/N)
MCV Vegetation Alliance or Habitat Type[a,b]	**Temporary[c]**	**Long-term Temporary[d]**	**Permanent[e]**	
Avalon Canyon Access Road				
Coyote brush and seaside wooly sunflower scrub+ *Baccharis pilularis and Eriophyllum staechadifolium Shrubland Alliance*	-	-	0.1029	Y
Disturbed/Developed	0.1072	-	0.0053	N/A

NOTES: Y=Yes; N=No; N/A=Not Applicable

a Sawyer, J.O., T. Keeler-Wolf, and J.M. Evens. 2009. A Manual of California Vegetation, Second Edition. California Native Plant Society, Sacramento, CA. 1300 pp.

b Shaded alliance row indicates potential ESHA; * indicates wetland; + indicates CDFW sensitive alliance

c All temporary impacts require that 1) there be no significant ground disturbance, and 2) that vegetation recovers to comparable age classes and/or size structure distributions by the end of the designated period (i.e., short term or long term). Short-term temporary impacts are those where vegetation recovery occurs within 12 months of the initial point of disturbance. Assumes site restoration requirement of 1:1 (acres mitigated : acres impacted).

d Long-term temporary impacts are those that may be intermittent or sustained for up to a 24-month period such that vegetation recovery may require more than 12 months from the initial point of disturbance but no more than 12 months from the conclusion point of disturbance, thus effectively allowing for as much as 36 months to fully recover. Assumes site restoration requirement of 1.5:1 (acres mitigated : acres impacted), based upon staff report for CDP application 2-20-0281 (Caltrans Gleason Beach Highway 1 Realignment). Available at: https://documents.coastal.ca.gov/reports/2020/11/F10a/F10a-11-2020-report.pdf.

e Permanent impacts include areas or key ecological functions that would be lost to development, frequently disturbed in order to maintain development, involve significant ground disturbance, or necessitate more than 12 months for recovery following the conclusion of disturbance. Assumes site restoration requirement of 3:1 (substantial restoration) or 6:1 (enhancement) for upland ESHA and 4:1 (substantial restoration) for wetland ESHA based on guidance received from and correspondence with Commission staff.

location in 2021 and 2022 did not identify existing populations of special-status dune plants that have been previously reported/mapped in the vicinity of Impound Lake (Nomad 2011; San Francisco spineflower occurrence po41814 [CNDDB, 2022]; see Appendix B, Figure 8) which suggests that existing habitat conditions coupled with the ongoing use of this area does not support the continuance of such species. Although sediment in this area may be sandy and support a greater proportion of dune plants than surrounding alliances (primarily iceplant), it does not function as a dynamic coastal dune, but rather similarly to other adjacent upland alliances (i.e., annual grassland or developed areas). Further investigation into the surface and subsurface substrate of the ice plant mat alliance along the Canal to determine whether significant fine sediment or gravel is present (suggesting these areas are not dunes) may support removing this alliance where present along the Canal from the list of potential ESHA – and nullify the mitigation requirements associated with Project impacts to such areas.

3.1.2 Trees

A tree inventory and assessment of the Project construction disturbance area was conducted in 2020 which identified 79 trees; 51 of these trees are proposed for removal from the Canal construction disturbance area (ESA, 2020c). These trees planned for removal include 31 Monterey pine, 8 coast live oak, 5 Myoporum, 2 blackwood acacia, 2 blue oak, 1 California buckeye, and 2 Monterey cypress. As mitigation for trees removed, and in compliance with EIR/EIS mitigation measure 3.4-6, Implement Tree Protection Measures and Plant Replacement Trees, that requires a 1:1 replacement for trees removed, the Project will plant 51 coast live oak trees (or combination of other native tree species commonly found in coast live oak woodlands) within the Canal coastal scrub uplands restoration area.

3.1.3 Restoration Areas

Construction disturbance areas that do not contain new, permanent Project infrastructure will be restored onsite to approximate pre-construction conditions (or better where non-native or invasive vegetation alliances are present). **Appendix C**, Figures 1 through 11, show the planting and hydroseeding areas within the Project limits associated with construction disturbance that will be restored under this Plan. **Table 3-3** depicts impacted vegetation alliances, mitigation ratios based on the category of impact, and estimated total compensatory mitigation obligations per alliance resulting from Project construction. Additional mitigation lands that will be developed within Fort Funston and Avalon Canyon as compensation for Project impacts beyond onsite restoration of construction disturbance areas will be identified at a future time, in coordination with respective land managers.

- A total of 0.128 acre freshwater marsh wetlands (California bulrush marsh and smartweed – cocklebur patches)[6] and 0.274 acre arroyo willow riparian wetlands (arroyo willow thickets)[7] will restored at their respective Lake Merced construction impact location(s) under this Plan. These one-parameter wetlands[8] have been delineated as waters of the State and confirmed by the SFBRWQCB.[9] An additional 0.116 acre freshwater marsh wetlands[10] and 0.920 acre arroyo willow wetlands[11] required as compensatory mitigation for permanent impacts and temporal loss of habitat function beyond onsite restoration will be created within the Lake Merced system through Project operation (see Section 6 for details). An additional 0.246 acre wetlands will be created during Project operation as compensation for permanent impacts to 0.0616 acre arroyo willow thicket along the Canal.
- A total of 0.381 acre of vegetation bordering the Canal (identified as waters of the State) will be restored within the construction impact location as riparian banks under this Plan. An additional 4.454 acre of coastal scrub uplands will be restored adjacent to the riparian banks within the construction disturbance area between the Canal and John Muir Drive.

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6 This total reflects the sum of the greatest possible impacts to freshwater marsh wetlands with the use of PRGC staging option B. Therefore, if staging option A is used, the impacts on this wetland type will be less than presented herein.

7 This total reflects the sum of the greatest possible impacts to arroyo willow riparian wetlands with the use of PRGC staging option A. Therefore, if staging option B is used, the impacts on this wetland type will be less than presented herein.

8 One-parameter wetlands considered waters of the State are characterized by having either hydrology, hydric soils, or hydrophytic vegetation (as identified on the current USACE National Plant List), rather than wetlands containing all three parameters which would qualify as waters of the U.S.

9 Clean Water Act Section 401 Water Quality Certification and Order for the Vista Grande Drainage Basin Improvement Project, San Francisco County. RM: 447730. Place ID: 881245. WDID No. 2 CW447730. Corps File No. 2014-00030S. Effective July 8, 2022.

10 This total reflects the sum of the greatest possible impacts to freshwater marsh wetlands with the use of PRGC staging option B. Therefore, if staging option A is used, the impacts on this wetland type will be less than presented herein.

11 This total reflects the sum of the greatest possible impacts to arroyo willow riparian wetlands with the use of PRGC staging option A. Therefore, if staging option B is used, the impacts on this wetland type will be less than presented herein.

TABLE 3-3
CONSTRUCTION IMPACT SUMMARY AND COMPENSATORY MITIGATION ESTIMATES FOR POTENTIAL ESHA

Potential ESHA Resource	Impact (ac) T/LTT/P [a]	Mitigation Ratio [b]	Compensatory Mitigation (ac)	Onsite Restoration (ac)	Additional Creation (ac) [c]	Total Restoration (ac)
Lake Merced Wetlands						
California bulrush marsh *Schoenoplectus californicus Herbaceous Alliance*	0.039 (Opt. A) 0.050 (Opt. B) (LTT)	1.5:1	0.058 (A) 0.074 (B)	0.095 (A) 0.106 (B)	0.015 (A) 0.020 (B)	0.110 (Opt. A) 0.126 (Opt. B)
	0.013 (P)	4:1	0.052			
Smartweed – cocklebur patches *Polygonum (=Persicaria) lapathifolium – Xanthium strumarium Herbaceous Alliance*	0.077 (Opt. A) 0.079 (Opt. B) (LTT)	1.5:1	0.115 (A) 0.118 (B)	0.020 (A) 0.022 (B)	0.095 (A) 0.096 (B)	0.115 (Opt. A) 0.118 (Opt. B)
Subtotal freshwater marsh wetlands				0.115 (A) 0.128 (B)	0.109 (A) 0.116 (B)	0.224 (A) 0.244 (B)
Arroyo willow thickets *Salix lasiolepis Shrubland Alliance*	0.030 (Opt. A) 0.007 (Opt. B) (LTT)	1.5:1	0.045 (A) 0.011 (B)	0.274 (A) 0.250 (B)	0.920 (A) 0.907 (B)	1.192 (Opt. A) 1.157 (Opt. B)
	0.287 (P)	4:1	1.147			
Canal						
Ice plant mats *Mesembryanthemum spp. – Carpobrotus spp. Herbaceous Semi-Natural Alliance*	1.012 (LTT)	1.5:1	1.518	-	4.188 (added to FF dune mitigation area)	4.188
	0.890 (P)	3:1	2.671			
Arroyo willow thickets *Salix lasiolepis Shrubland Alliance*	0.0616 (P)	4:1	0.246	-	0.246 (added to shoreline)	0.246
Coast live oak forest and woodland *Quercus agrifolia Forest and Woodland Alliance*	0.369 (P)	3:1	1.108	4.454 coastal scrub uplands 0.381 riparian	-	4.454 coastal scrub uplands 0.381 riparian
Other Vegetation Impacts [d]	4.119	1:1	4.119			
Fort Funston Tunnel Staging Area						
Silver dune lupine – mock heather scrub *Lupinus chamissonis - Ericameria ericoides Shrubland Alliance*	1.926 (P)	3:1	5.779	1.926	3.853	5.779
Ice plant mats *Mesembryanthemum spp. – Carpobrotus spp. Herbaceous Semi-Natural Alliance*	2.260 (P)	3:1	6.781	2.260	4.521	6.781
Ocean Outlet						
Ice plant mats *Mesembryanthemum spp. – Carpobrotus spp. Herbaceous Semi-Natural Alliance*	0.060 (LTT)	1.5:1	0.089	0.060	0.030 (added to FF dune restoration area)	0.089

TABLE 3-3 (CONTINUED)
CONSTRUCTION IMPACT SUMMARY AND COMPENSATORY MITIGATION ESTIMATES FOR POTENTIAL ESHA

Potential ESHA Resource	Impact (ac) T/LTT/P [a]	Mitigation Ratio [b]	Compensatory Mitigation (ac)	Onsite Restoration (ac)	Additional Creation (ac) [c]	Total Restoration (ac)
Avalon Canyon Access Road						
Coyote brush and seaside wooly sunflower scrub[+] *Baccharis pilularis and Eriophyllum staechadifolium Shrubland Alliance*	0.103 (P)	3:1	0.309	0.091	0.218	0.309

NOTES:
[a] T = Temporary; LTT = Long-term Temporary; P = Permanent; FF = Fort Funston
[b] All temporary impacts require that 1) there be no significant ground disturbance, and 2) that vegetation recovers to comparable age classes and/or size structure distributions by the end of the designated period (i.e., short term or long term). Short-term temporary impacts are those where vegetation recovery occurs within 12 months of the *initial* point of disturbance. Long-term temporary impacts are those that may be intermittent or sustained for up to a 24-month period such that vegetation recovery may require more than 12 months from the *initial* point of disturbance but no more than 12 months from the *conclusion* point of disturbance, thus effectively allowing for as much as 36 months to fully recover. Assumes site restoration requirement of 1.5:1 (acres mitigated : acres impacted), based upon staff report for CDP application 2-20-0281 (Caltrans Gleason Beach Highway 1 Realignment). Available at: https://documents.coastal.ca.gov/reports/2020/11/F10a/F10a-11-2020-report.pdf. Permanent impacts include areas or key ecological functions that would be lost to development, frequently disturbed in order to maintain development, involve significant ground disturbance, or necessitate more than 12 months for recovery following the *conclusion* of disturbance. Assumes site restoration requirement of 3:1 for upland ESHA, 4:1 for wetland ESHA based on guidance received from and correspondence with Commission staff.
[c] This column contains the additional acreage required to fulfill the compensatory mitigation requirements for construction disturbance impacts after restoration of the temporary use areas (quantities within the "Onsite Restoration" column).
d "Other vegetation" includes all vegetation types (and their acreage) not identified as potential ESHA.

SOURCE: ESA, 2020. Memorandum: Vista Grande Drainage Basin Improvement Project: Delineation of Wetlands and Waters Subject to California Coastal Commission Jurisdiction. December 4, 2020.
Garske-Garcia, Lauren, Ph.D. – Senior Ecologist. Memorandum: Impact Definitions and Mitigation Framework for Gleason's Beach Highway 1 Realignment. California Coastal Commission. October 8, 2020.

- A total of 4.835 acres will be revegetated along the Canal. The intent of revegetating this area with native coastal scrub species is to functionally lift the area that was an assemblage of some native, mostly non-native and invasive species prior to construction. A combination of regionally appropriate, native tree species, that includes coast live oak trees, will be planted within this disturbance area as mitigation for 51 trees (both native and non-native) removed from this area during construction (ESA, 2020c). The combination of planting coast live oak trees and seeding native coastal scrub species at this location is proposed as compensatory mitigation for Project impacts to coast live oak woodland along the Canal and other vegetation removed from this location under the Project that was not identified as potential ESHA. A total of 4.188 acres of dunes within the Fort Funston dune mitigation area described below will compensate for long-term temporary and permanent impacts to ice plant mats within the Canal construction disturbance area. Wetlands created along the lake shoreline during Project operation will compensate for construction impacts to 0.0616 acre arroyo willow thicket along the Canal (discussed above; see Section 6 for further explanation of wetland compensatory mitigation fulfillment through Project operation).

- A total of 16.810 acres silver dune lupine – mock heather scrub (or similar) will be restored within Fort Funston under this Plan. This consists of onsite restoration of 1.926 acres silver dune lupine – mock heather scrub and 2.2604 acres ice plant mats impacted within the tunnel staging area, 0.060 acre ice plant mats impacted by the ocean outlet construction (blufftop staging area), and an additional 12.562 acres[12] native dune habitat created/substantially restored within Fort Funston (location[s] to be identified by and coordinated with the National Park Service).

- A total of 0.309 acre coyote brush and seaside wooly sunflower scrub will be restored within Avalon Canyon under this Plan. This consists of 0.091 acre restoration of the construction work area footprint and an additional 0.218 acre substantially restored or created as compensatory mitigation for permanent impacts to this vegetation alliance resulting from necessary road repairs.

Once construction is complete, the temporarily disturbed construction sites will be graded to match their approximate pre-Project topography. The lake's wetland and riparian areas, Canal riparian banks and adjacent uplands, tunnel staging area dunes and the Avalon Canyon disturbance area will then be prepared for revegetation. New mitigation areas within Fort Funston and Avalon Canyon will include removal of existing non-native or invasive vegetation, soil preparation (e.g., light manipulation and amendment), grading, and planting or seeding. The Restoration Monitor (described in Section 4.2) will use high accuracy Global Positioning System (GPS) equipment to direct the restoration contractor in site preparation and layout prior to planting, seeding or hydroseeding each of these areas according to the restoration plans for each location (see Section 4).

3.2 Shoreline Vegetation Response to Restoration of Historic Lake Merced Water Levels

The contents of this section support **Appendix D**, Figures 1 through 8**,** depicting Lake Merced shoreline vegetation alliance polygons and Vista Grande Drainage Basin Improvement Project operational WSE scenarios, represented by elevation bands at 6.0 feet (baseline conditions), and a range of potential operational water levels from 8.0 feet to 9.0 feet City Datum. This analysis relies on vegetation mapped within the Lake Merced system in 2011 under the *Lake Merced Vegetation Mapping Update*, an effort which refreshed previous vegetation maps of the Lake Merced system initiated in 2000.[13] The initial vegetation maps and classification system used the Manuel of California Vegetation (MCV), first edition, and classified vegetation into 44 discrete vegetation types, or series.[14] The 2011 update used the MCV second edition and classified vegetation to the alliance level or a more detailed vegetation type based on the initial 44 series mapped. [15] For consistency, the naming convention used in the initial mapping effort was retained for the mapping update. The vegetation was mapped in a GIS platform using digital color aerial photography, field notes, and delineating the boundaries around individual stands of vegetation through a 'heads up'

[12] The 12.562 acres of created dune habitat is compensatory mitigation for impacts to dune habitat within Fort Funston beyond onsite restoration of the tunnel staging area (8.374 acres) and within the construction disturbance area along the Canal (4.188 acres).

[13] Nomad Ecology, 2011. Lake Merced Vegetation Mapping Update, Lake Merced Natural Area, City and County of San Francisco, California, revised draft. Prepared for San Francisco Public Utilities Commission, May.

[14] Sawyer and Keeler-Wolf, 1995. A Manual of California Vegetation. California Native Plant Society. Sacramento, USA.

[15] A classification of vegetation at any level in the National Vegetation Classification Hierarchy (e.g. alliance, association) or used when vegetation has not been classified formally to a specific level. A vegetation type is typically defined on the basis of shared floristic and/or physiognomic characteristics.

digitizing process, followed by ground truthing nearly half of the vegetation polygons. ESA obtained this spatial data from the City of San Francisco to support the Project EIR/EIS impact analysis.

Surveys conducted of the Project construction areas around the lake between 2012 and 2021 have updated vegetation mapping at discrete locations within this dataset. This dataset remains the most comprehensive and best scientific data available and is sufficiently detailed to support the modeling assessment of vegetation response to operational WSEs to understand the magnitude of potential vegetation change. Although CCC staff has requested updated mapping to better understand current conditions (2022), replicating the 2011 mapping effort would be at substantial cost and of limited value given the similarity of water levels in 2011 and today (approximately 6 feet City Datum) that could influence shoreline vegetation composition. Further, because Project operations and higher lake levels will not be achieved for several years, any updated mapping effort conducted ahead of Project operations would be similarly outdated (by Commission standards preferring data within five years). The City expects to conduct updated mapping closer to the start of Project operation, to provide a more accurate baseline against which to assess vegetation response to higher lake levels. This approach to establishing an updated baseline dataset from which shoreline vegetation response to operational WSE will be measured is discussed in Section 6.

To support the analysis herein, findings from the EIR/EIS vegetation change analysis, which examined the response of shoreline vegetation communities to increased and sustained water surface elevations, have been applied to shoreline vegetation alliances where applicable. Wetland vegetation alliances are expected to migrate in response to higher operational WSEs. **Table 3-4** depicts these wetland alliances' predicted response (net change) to restored lake levels, as previously presented in the EIR/EIS. Upland vegetation alliances inundated by restored WSE are considered permanently lost as they are not expected to move upslope in response to rising lake levels. **Table 3-5** and **Table 3-6** present the potential aerial extents of impacts from inundation to these upland communities.

These tables are presented for informational purposes in response to the Commission's request, recognizing that the change amounts (acre[s]) are uncertain in extent, timing, and duration, and reflect the vegetation response assumptions made in the EIR/EIS modeling of operational scenarios. Actual changes in shoreline vegetation are too speculative to predict unless and until operational lake levels are restored (water permitting) and sustained long enough for vegetation response to be realized.

The lake levels will be managed during Project operation in a manner that will result in a net ecosystem benefit. Based upon the above mentioned EIR/EIS modeling, the Project's restoration of historic lake levels is predicted to compensate for the permanent loss of wetlands (identified as waters of the State) that could result from construction phase installation of new Project infrastructure (see Section 3.1.1). This will be accomplished through the expansion of both open water habitat and herbaceous wetlands. The changes to shoreline vegetation in response to higher lake levels are not considered to be "impacts" because the Project's operational scenarios will be restoring historic water surface elevation – and by extension, the associated vegetation communities – to Lake Merced. The Project approach to monitoring vegetation response to operational lake levels is described in Section 6.

3.2.1 Wetland Vegetation Alliances Modeled for Response to Restored WSE

The wetland vegetation alliances included in Table 3-4 were modeled for response to increased WSE under operational scenarios considered in the Project EIR/EIS (see Table 3.4-7). Table 3-4 presents modeling results relevant to the discussion of the influence restoration of historic lake levels will have on shoreline vegetation alliances, as requested by CCC staff. Collectively, the total area of cover for the wetland vegetation alliances in Table 3-4 is predicted to increase as a result of Project operations by between approximately 2 and 4 acres, though the area of cover for several individual alliances is predicted to decrease by fractions of an acre. The exception is the predicted response from arroyo willow thickets, whose coverage could experience a reduction of between roughly 5 and 9 acres depending on the operational WSE scenario. California bulrush marsh wetland is the alliance predicted to expand the most with an increase in coverage between about 7 and 13 acres. All the wetland alliances included in Table 3-4 are assumed to be potential ESHA.

TABLE 3-4
PREDICTED CHANGE IN WETLAND VEGETATION ALLIANCE COVERAGE AND DISTRIBUTION (ACRES) AND PERCENT CHANGE RELATIVE TO A 6-FOOT WATER SURFACE ELEVATION: RISING WATER LEVELS

Manual of California Vegetation Alliance[a]	Mapped Shoreline Vegetation above 6.0 feet WSE (City Datum) (ac)	Predicted Shoreline Vegetation above 8.0 and 9.0 feet WSE (City Datum) (ac) and Percent Change from Current Conditions[b,c,d,e]	
(EIR/EIS Vegetation Community Type)	6.0 feet (Baseline)	8.0 feet	9.0 feet
California bulrush marsh (Bulrush wetland)*+ *Schoenoplectus californicus Herbaceous Alliance*	25.05	**32.57 (+7.52)**	**38.18 (+13.13)**
Percent Change	-	+30%	+52.4%
Arroyo willow thickets (Arroyo willow riparian scrub)*+ *Salix lasiolepis Shrubland Alliance*	17.03	*11.86 (-5.17)*	*8.44 (-8.59)*
Percent Change	-	-30.4%	-50.4%
Smartweed – cocklebur patches (Knotweed wetland)*+ *Polygonum lapathifolium – Xanthium strumarium Herbaceous Alliance*	7.02	*6.89 (-0.13)*	*6.13 (-0.89)*
Percent Change	-	-1.8%	-12.6%
Slough sedge – Water-parsley – Small-fruited bulrush marsh (Rush meadow)*+ *Juncus lescurii Herbaceous Alliance*	0.40	*0.31 (-0.09)*	*0.26 (-0.14)*
Percent Change	-	-22.5%	-35.0%
NA - Giant vetch (Giant vetch wetland)* *NA - Vicia gigantea*	0.25	*0.17 (-0.08)*	*0.16 (-0.09)*
Percent Change	-	-32.0%	-36.0%
Cattail marshes (Cattail wetland)* *Typha (angustifolia, domingensis, latifolia) Herbaceous Alliance*	0.01	*0.00 (-0.01)*	*0.00 (-0.01)*
Percent Change	-	-100%	-100%
Total Herbaceous Wetland *Net increase in herbaceous shoreline wetlands under either operational scenario.*	32.73	**39.94 (+7.21)**	**44.73 (+12.0)**
Percent Change		+22.0%	+36.7%

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Manual of California Vegetation Alliance[a] (EIR/EIS Vegetation Community Type)	Mapped Shoreline Vegetation above 6.0 feet WSE (City Datum) (ac) 6.0 feet (Baseline)	Predicted Shoreline Vegetation above 8.0 and 9.0 feet WSE (City Datum) (ac) and Percent Change from Current Conditions[b,c,d,e] 8.0 feet	 9.0 feet
Total wetland (riparian + herbaceous) *Net increase in total wetlands (including riparian wetlands) under either operational scenario.*	49.76	**51.80 (+2.04)**	**53.17 (+3.41)**
Percent Change		+4.3%	+7.2%
Open Water *Net increase in ~ 10 acres open water habitat under either operational scenario.*	256.40	**266.15 (+9.75)**	**266.46 (+10.06)**
Percent Change		+3.8%	+3.9%

NOTES:

a **Bold alliance** indicates potential ESHA; * indicates wetland; + indicates CDFW sensitive alliance

b Acreages in table are for vegetation at and below 10 feet City Datum.

c Values in **bold** indicate an increase in cover type

d Values in italic indicate a decrease in cover type.

e Predicted vegetation change is measured against a baseline 6-foot City Datum mean annual water surface elevation which is within the range of average water levels between 2006 and 2021. Drought conditions beginning in 2020 have resulted in lower average WSE in 2021 and 2022. The 2022 water levels reported through September ranged between 5.5 and 4.3 WSE (SFPUC 2022).

SOURCE: Nomad 2011

3.2.2 Changes in Upland Vegetation Alliances Under Restored Operational WSE

Large non-native eucalyptus trees along the shores of North and South Lakes support several double crested cormorant and great blue heron rookeries. These trees may be determined ESHA by the Commission based upon the rarity and vulnerability of rookeries to human disturbance. The project EIR/EIS (Table 3.4-8) presented the predicted response of this vegetation to increased WSE under operational scenarios. Table 3-5, below, presents the portions of that information relevant to the discussion of shoreline vegetation alliance changes associated with restored lake levels, as requested by the CCC staff. Since the EIR/EIS vegetation mapping relies on aerial photograph interpretation of the canopy, and individual eucalyptus stems were not mapped, EIR/EIS Table 3.4-8 and Table 3-5, below, likely overestimates the potential extent of habitat conversion at selected operational WSEs. During the 2012 field assessment upon which the EIR/EIS relies for the vegetation acreages, healthy eucalyptus trees were documented at the high-water line (~6 feet City Datum). Most eucalyptus trees are located at higher elevations than that, and on steeper slopes where the trunks may be located well above the 8-foot contour. Predicted vegetation die-off for this community would begin after one month of inundation. Restoration of lake levels will alter rookeries in eucalyptus forest at North Lake (predicted to be a complete loss from inundation) and South Lake (room for rookery to move upslope into existing eucalyptus forest above the operational WSEs). Field surveys to monitor the response of individual trees and associated viability of the rookery would more accurately document the operational impacts of increased WSE on the rookeries. Monitoring the response of this community to higher lake levels where rookeries are present to document whether they cease functioning as a result of increased WSE is included in the operational monitoring program, described in Section 6.

TABLE 3-5
PREDICTED CHANGE IN BLUE GUM EUCALYPTUS FOREST COVERAGE AND DISTRIBUTION (ACRES) AND PERCENT CHANGE RELATIVE TO A 6-FOOT WATER SURFACE ELEVATION: RISING WATER LEVELS

Manual of California Vegetation Alliance[a] (EIR/EIS Vegetation Community Type)	Mapped Shoreline Vegetation above 6.0 feet WSE (City Datum)	Predicted Shoreline Vegetation above 8.0 and 9.0 feet WSE (City Datum) (ac) and Percent Change from Current Conditions[b,c]	
	6.0 feet	8.0 feet	9.0 feet
Blue gum eucalyptus groves *Eucalyptus globulus Semi-Natural Woodland Stands* **(Eucalyptus forest)**	17.63	*15.79 (-1.84)*	*14.93 (-2.7)*
Percent Change	-	-10.6%	-15.6%

NOTES:
[a] **Bold alliance** indicates potential ESHA; * indicates wetland; + indicates CDFW sensitive alliance
[b] Values in italic indicate a decrease in cover type.
[c] Due to the canopy cover over the lake shoreline, the predicted change for blue gum eucalyptus is likely overestimated.

SOURCE: Nomad 2011

Prolonged inundation of the vegetation alliances included in Table 3-6, generally considered to be upland vegetation, is assumed to be permanent, in that they are not expected to migrate upslope in response to rising water surface elevation under Project operations. Several upland alliances are identified as potential ESHA; although, as shown in the table, the impact quantities for these alliances at any operational scenario are fractions of an acre. Table 3-6 relies on the same mapping that supported the EIR/EIS and the predicted vegetation change analysis presented in Tables 3-4 and 3-5. The estimates presented in Table 3-6 reflect the extent of vegetation change relative to that under the 6.0 foot WSE for each of the 8.0, 8.5, and 9.0 foot operational WSE scenarios.

TABLE 3-6
UPLAND VEGETATION ALLIANCES OF LAKE MERCED SHORELINE AND OPERATIONAL WSE

Manual of California Vegetation Alliance[a]	Mapped Shoreline Vegetation above 6.0 feet WSE (City Datum) (ac)[b]	Predicted Changes in Shoreline Vegetation (ac) per WSE (Percent Loss of Total Mapped)[c]		
		8.0 ft WSE	8.5 ft WSE	9.0 ft WSE
NA - Mixed exotic forest	22.25	*0.62 (2.80%)*	*0.95 (4.27%)*	*1.26 (5.67%)*
Monterey cypress - Monterey pine woodland stands (ruderal) *Hesperocyparis macrocarpa - Pinus radiata Forest & Woodland Semi-Natural Alliance*	7.18	*0.18 (2.46%)*	*0.24 (3.36%)*	*0.30 (4.11%)*
California blackberry Shrubland Alliance*+ *Rubus ursinus Shrubland Alliance*	7.23	*0.16 (2.22%)*	*0.28 (3.94%)*	*0.43 (6.10%)*
NA - Mixed exotic herbaceous	5.56	*0.04 (0.75%)*	*0.08 (1.48%)*	*0.11 (2.02%)*
Choke cherry thickets+ [d] *Prunus virginiana Provisional Shrubland Alliance*	0.22	*0.02 (10.08%)*	*0.03 (12.54%)*	*0.03 (14.69%)*

TABLE 3-6 (CONTINUED)
UPLAND VEGETATION ALLIANCES OF LAKE MERCED SHORELINE AND OPERATIONAL WSE

Manual of California Vegetation Alliance[a]	Mapped Shoreline Vegetation above 6.0 feet WSE (City Datum) (ac)[b]	Predicted Changes in Shoreline Vegetation (ac) per WSE (Percent Loss of Total Mapped)[c]		
		8.0 ft WSE	**8.5 ft WSE**	**9.0 ft WSE**
Myoporum groves *Myoporum laetum Semi-Natural Woodland Stands*	0.74	*0.02 (2.66%)*	*0.04 (4.97%)*	*0.05 (6.68%)*
Coyote brush Shrubland Alliance *Baccharis pilularis Shrubland Alliance*	5.16	*0.01 (0.12%)*	*0.02 (0.32%)*	*0.03 (0.66%)*
Yellow bush lupine scrub *Lupinus arboreus Shrubland Alliance, in part*	3.30	*0.01 (0.17%)*	*0.01 (0.26%)*	*0.01 (0.37%)*
Australian wattle – Grevillea – Tea tree ruderal patches *Acacia spp. - Grevillea spp. - Leptospermum laevigatum Shrubland Semi-natural Alliance*	2.06	*0.01 (0.51%)*	*0.16 (7.65%)*	*0.20 (9.70%)*
Himalayan blackberry – rattlebox – edible fig riparian scrub *Rubus armeniacus Semi-Natural Shrubland Stands*	0.23	*0.01 (5.26%)*	*0.02 (8.25%)*	*0.15 (66.58%)*
Ice plant mats *Carpobrotus edulis Semi-Natural Herbaceous Stands*	4.69	*0.01 (0.25%)*	*0.05 (1.08%)*	*0.11 (2.30%)*
Poison oak scrub *Toxicodendron diversilobum Shrubland Alliance*	0.28	*<0.01 (1.59%)*	*0.02 (5.56%)*	*0.05 (17.27%)*
Poison hemlock patches *Conium maculatum Semi-Natural Herbaceous Stands*	0.77	*<0.01 (0.05%)*	*0.01 (1.62%)*	*0.02 (2.48%)*
Other Mustards Semi-Natural Herbaceous Stands	1.20	*<0.01 (0.14%)*	*<0.01 (0.37%)*	*0.01 (0.63%)*
Coyote brush – lizard tail scrub+ *Baccharis pilularis Shrubland Alliance (Baccharis pilularis / Eriophyllum staechadifolium)*	0.15	*<0.01 (0.60%)*	*<0.01 (1.66%)*	*<0.01 (2.60%)*
Wax myrtle scrub+ *Morella californica Shrubland Alliance*	0.08	-	*<0.01 (<0.00%)*	*<0.01 (2.03%)*
NA – Vancouver rye grassland+ *NA - Elymus × vancouverensis*	0.01	-	*<0.01 (0.79%)*	*<0.01 (8.66%)*
Canyon live oak shrubland+ *Quercus chrysolepis Shrubland Alliance (in part)*	0.13	-	-	*<0.01 (0.07%)*
Ripgut brome Semi-Natural Herbaceous stand *Bromus diandrus Semi-Natural Herbaceous Stand*	0.99	-	-	*0.06 (6.53%)*
No Impacts to Below Vegetation Alliances Under Operational Scenarios				
Mixed oak forest and woodland+ *Quercus agrifolia Woodland Alliance*	0.54	**-**	**-**	**-**

TABLE 3-6 (CONTINUED)
UPLAND VEGETATION ALLIANCES OF LAKE MERCED SHORELINE AND OPERATIONAL WSE

Manual of California Vegetation Alliance[a]	Mapped Shoreline Vegetation above 6.0 feet WSE (City Datum) (ac)[b]	Predicted Changes in Shoreline Vegetation (ac) per WSE (Percent Loss of Total Mapped)[c]		
		8.0 ft WSE	8.5 ft WSE	9.0 ft WSE
Thimbleberry brambles+ *Rubus parviflorus Shrubland Alliance*	0.34	-	-	-
Wild oat annual grassland *Avena fatua Semi-Natural Herbaceous Stand*	0.27	-	-	-
California rose briar patches+ *Rosa californica Shrubland Alliance*	0.17	-	-	-
NA - Cape ivy patches NA - Delairea odorata	0.03	-	-	-
Hazelnut scrub+ Corylus cornuta var. californica Shrubland Alliance	0.02	-	-	-

NOTES:

a **Bold alliance** indicates potential ESHA; * indicates wetland; + indicates CDFW sensitive alliance
b Data collected in 2010 by Nomad and provided to ESA by SFPUC for use in the EIR/EIS. Dataset modified in 2012 and 2021 to reflect updates to the Project aquatic resources delineation and current field conditions at the Pacific Rod and Gun Club staging area and Lake Merced Overflow Structure in South Lake and Outlet Structure in Impound Lake.
c Values in italic indicate a decrease in cover type.
d Choke cherry thickets has provisional status as a CDFW sensitive alliance; CCC may identify it as ESHA for this reason. Not identified in the EIR/EIS as a Sensitive Natural Community.

SOURCE: Nomad 2011

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SECTION 4

Restoration Methods for Temporarily Disturbed Areas

Revegetation of temporarily disturbed freshwater marsh and arroyo willow riparian wetlands at Lake Merced will be achieved using locally harvested materials: wetland plants and seeds, and willow stakes. A combination of seed application and vegetative and reproductive propagules will be used for freshwater marsh restoration. Vegetative propagules (rhizome material with attached stems and leaves) are expected to establish well in the restoration areas while seed planting of wetland species is a secondary approach with an unknown outcome intended to bolster overall pace of restoration. The outcome of the secondary direct seeding approach using seeds collected from the impact area and nearby shoreline is uncertain due to the lack of direct seeding case studies from the Project area, low seed production, and the complex seed dormancy and germination requirements of perennial wetland plants. The temporarily disturbed Canal riparian banks and adjacent uplands between the Canal and John Muir Drive and Avalon Canyon restoration areas will be hydroseeded using a custom seed mix of native species from a local seed supplier. Mitigation tree plantings will consist of regionally appropriate, native species in a variety of sizes. Dunes within Fort Funston will be restored through a combination of vegetative propagules and seeding of local, native dune species. The approximate layout of the anticipated revegetation planting areas is shown in Figures 1 through 11 (Appendix C). Freshwater marsh wetlands will be revegetated with the same species that are currently present (California bulrush and swamp knotweed) along the shoreline impact areas at South Lake and Impound Lake. Along these same shoreline impact areas at higher elevation, arroyo willow riparian wetlands will be planted with arroyo willow stakes. The Canal riparian banks and adjacent uplands hydroseed mix is representative of native species typical of regional riparian corridors and coastal scrub uplands and considers the existing vegetation within the Canal disturbance area and the adjacent vegetation above the top of banks. Live plantings and native seed mix selected to restore the temporarily disturbed Fort Funston dunes are representative of native species that have been successful in other restoration efforts implemented within the park by the National Park Service. The hydroseed mix selected for the Avalon Canyon restoration areas is representative of native species observed within the canyon or other similar, local coastal scrub habitats.

The following sections identify the revegetation schedule, role of the restoration monitor, plant material sources and collection methods, site preparation methods, and planting information. No irrigation of restoration areas or plantings is proposed under this Plan due to the location of restoration areas and species composition selected for these individual sites, which consider existing water sources and local climate. Detailed plans and specifications for revegetation will be developed prior to the commencement of Project construction to assist the contractor in correct installation locations, spacing, methods, materials, and schedule. The plans and specifications will be based on the methods and information in this Plan.

4.1 Revegetation Schedule

Project construction is currently scheduled to begin in summer 2023 and take place over approximately 24 to 44 months.[16] **Table 4-1** provides the anticipated timeframes for seed and plant collection and installation, based on the construction schedule and phasing at various impact locations.

- Construction at Impound Lake on the outlet structure is planned to begin in April 2023 and be completed in March 2025.
- Construction at South Lake on the overflow structure is planned to begin in June 2025 and be completed in November 2025.
- Construction along the Canal is planned to begin in July 2023 and be completed in December 2025.
- Construction at the Ocean Outlet and Project use of the tunnel staging area at Fort Funston is planned to begin November 2024 and be completed in April 2026.
- Construction within Avalon Canyon to repair the access road is planned to begin January 2025 and be completed in the same month.

TABLE 4-1
ANTICIPATED RESTORATION MATERIAL COLLECTION AND INSTALLATION SCHEDULE

Activity	Location/Timing	
	Lake Merced	
Seed Collection	Impound Lake	South Lake
California bulrush (*Schoenoplectus californicus*)	Summer 2023 (July-August) from onsite or offsite locations; summer 2025 from offsite locations	Summer 2024 (July-August) from onsite or offsite populations; summer 2025 from offsite locations
Swamp knotweed (*Persicaria amphibia*)	Summer 2023 (July-August) from Impound Lake site; summer 2025 from offsite locations	Summer 2024 (July-August)- from South Lake site or offsite populations; summer 2025 from offsite locations
Plant Harvest (vegetative)	Impound Lake	South Lake
California bulrush	September-October-November 2025 from offsite locations	September-October-November 2025 from offsite locations
Swamp knotweed	October-November 2025 from offsite locations	October-November 2025 from offsite locations
Arroyo willow (*Salix lasiolepis*)	October-November-December 2025 (or once plants are dormant and before bud break) from offsite populations	October-November-December 2025 (or once plants are dormant and before bud break) from offsite populations
Planting (vegetative)	Impound Lake	South Lake
California bulrush	September-October-November 2025	September-October-November 2025
Swamp knotweed	October-November 2025	October-November 2025
Arroyo willow	October-November-December 2025 immediately after harvest	October-November-December 2025 immediately after harvest

16 The Project construction schedule is subject to change; however, the duration of all monitoring and restoration efforts will remain the same. If updates to this Plan are necessary based on schedule revisions, ESA will notify the Regional Water Board, as appropriate.

TABLE 4-1 (CONTINUED)
ANTICIPATED RESTORATION MATERIAL COLLECTION AND INSTALLATION SCHEDULE

Activity	Location/Timing	
	Lake Merced (cont.)	
Seed Planting		
California bulrush	November-December 2025 after vegetative propagule planting	November-December 2025 after vegetative propagule planting
Swamp knotweed	November-December 2025 after vegetative propagule planting	November-December 2025 after vegetative propagule planting
	Vista Grande Canal	
Planting (vegetative)		
Coordinate with local nursery	October-November 2024	
Native trees	October-November 2025 (ahead of hydroseeding)	
Hydroseeding		
Coordinate with local seed supplier	October-November 2024	
Native riparian corridor and adjacent uplands seed mix	October-November 2025	
	Fort Funston	
Planting (vegetative)		
Coordinate with local nursery	October-November 2025	
Native coastal dune propagules	October-November 2026	
Broadcast Seeding		
Coordinate with local seed supplier	October-November 2025	
Native coastal dune scrub seed mix	October-November 2026	
	Avalon Canyon	
Hydroseeding		
Coordinate with local seed supplier	October-November 2024	
Native coastal scrub seed mix	January-February 2025	

4.2 Restoration Monitor

A qualified botanist, biologist, restoration ecologist, environmental scientist, or person with at least three years of experience implementing restoration plans will oversee and monitor implementation of this Plan. The Restoration Monitor will be responsible for:

- Being familiar with pre-project conditions (such as vegetation composition, presence of invasive species, percent cover, and general site conditions such as health and vigor of existing vegetation) to understand whether restored areas are performing well

- Selecting and documenting appropriate contemporary reference sites (outside, but nearby to, the areas of temporary impact) for each of the different impacted habitat types, for use in assessing final success
- Overseeing seed collection, cleaning, and storage
- Reviewing and approving seed lots and lab results prior to purchase
- Supervising site preparation
- Evaluating and determining which restoration measures will be implemented at each restoration site
- Directing plant harvest and planting
- Assisting with preparation of the restoration as-built drawings showing locations and quantities of installed willow stakes and seeded areas, during or immediately following planting activities, to support annual monitoring and performance tracking
- Conducting quarterly general site assessments to identify weeding maintenance tasks, trash or vandalism within restoration areas, and conducting the annual monitoring for the duration of the monitoring period
- Preparing annual reports
- Providing guidance and instruction to the City for ongoing maintenance to ensure the long-term successful establishment of the seeding and plantings
- Guiding remedial actions as needed, so that performance standards and permit conditions are met
- If necessary, the Restoration Monitor will train maintenance crews in the methods represented in this Plan including, but not limited to, proper techniques and best management practices for weed control

4.3 Seed Material and Application

4.3.1 Freshwater Marsh Wetlands

Seed Material

Seeds of swamp knotweed and California bulrush will be collected from the temporary impact areas prior to construction in an attempt to preserve the local genetic material and minimize the need to collect seeds from other nearby areas. Seeds should be collected in summer 2023 from Impound Lake and summer 2024 from South Lake for planting in fall and winter 2025 or early 2026 (see Table 4-1). Viability of seeds collected greater than a year prior to planting may be low by the time they are planted at the site and thus a second round of seed collection is proposed for summer 2025. If the temporary impact duration doesn't lend to harvesting seeds onsite, seeds can be collected from nearby sources around Lake Merced or in the larger Project vicinity (see definition of local seed source in Section 4.3.2).

For collecting California bulrush and swamp knotweed seeds outside of the temporary impact site, the following guidelines should be followed to protect source populations from over-collection (developed based on guidelines from GGNRA, 2012):

- Collect mature, filled seeds (seeds with a fully formed endosperm that can be observed when seeds are cut in half - magnification may be needed to see this).
- Collect no more than 5 percent of the available seed for each species, within the collection area. This will protect existing populations.
- Collect from many different individual plants. Collection from fifty plants is a good starting point, but collect from as many as possible and never fewer than 10 plants.
- Collect from several populations around Lake Merced, within different microclimates, aspects, and soil types, if possible.
- Clean and store seeds immediately to prevent damage. Remove any dead material and isolate seeds, storing in a dry container in a cold location (40°F) such as a refrigerator.

An estimate of the number of seeds required is based on a conservative five seed per square foot planting design, and total area of temporary impact. This will result in 24,410 pure, live, seeds of California bulrush and 4,715 pure, live, seeds of swamp knotweed based on the impact and restoration area identified in Table 3-3 which is calculated based on a 1:1 (restored : impacted) mitigation ratio for onsite restoration of the construction disturbance area.

Broadcast Seed Application

Seeds of wetland plants (swamp knotweed and California bulrush) will be broadcast in their designated areas. Seeds can be broadcast by hand or by mechanical means (e.g., using a hopper with a material regulating system in the bottom that feeds seed at a given rate either onto a spinner or directly onto the soil). Broadcasting will meet the following specifications:

- Half the seed will be spread in one direction and the other half will spread in the other direction (i.e., first east-west or horizontally and then north-south or vertically)
- Broadcast seed will be raked, harrowed, chain dragged, or tracked into the soil as feasible to enhance seed to soil contact

4.3.2 Canal Riparian Banks and Coastal Scrub Uplands

Hydroseed Material

The Canal riparian banks and coastal scrub restoration areas will be hydroseeded with a custom seed mix of native, low-growing shrub and herbaceous species common to local riparian corridors. The anticipated seed mix for the Canal riparian banks and adjacent coastal scrub uplands is provided in **Table 4-2**.

TABLE 4-2
CANAL RIPARIAN BANKS AND COASTAL SCRUB UPLANDS SEED MIX

Scientific Name	Common Name	Percent of Seed Mix	Approximate Number of Pure Live Seeds (pounds per acre)
Achillea millefolium	Yarrow	5	0.5
Artemisia californica	California sage	5	0.5
Baccharis pilularis ssp. consanguinea	Prostrate coyote brush	10	0.15
Bromus carinatus	California brome	10	10.0
Carex praegracilis	Field sedge	5	2.5
Clarkia purpurea	Four-spot clarkia	5	1.0
Diplacus aurantiacus	Sticky monkeyflower	10	0.25
Elymus triticoides	Beardless wild rye	5	5.0
Eriophyllum staechadifolium	Seaside wooly sunflower	10	2.0
Eschscholzia californica	California poppy	5	1.5
Hordeum brachyantherum	Meadow barley	10	8.0
Juncus patens	Spreading rush	5	1.0
Madia elegans	Common madia	5	0.1
Salvia mellifera	Black sage	5	2.5
Scrophularia californica	California bee plant	5	1.0

The source of seeds will preferably be local and obtained from a restoration nursery or seed supplier in the greater San Francisco Bay Area. The local seed source is defined as within the central coast or San Francisco Bay geographic subregions of the California Floristic Province (Baldwin et al., 2012) and between Sonoma County in the north and Monterey County in the south. Nurseries that are likely to have locally sourced materials include, but are not limited to:

The Watershed Nursery
601 A Canal Blvd.
Richmond, Ca. 94804
(510) 234-2222
www.TheWatershedNursery.com

Larner Seeds
235 Grove Road
Bolinas, CA 94924
(415) 868-9407
www.larnerseeds.com

Pacific Coast Seed
533 Hawthorne Place
Livermore, CA 94551
(925) 373-4417
www.pcseed.com

Rana Creek Wholesale Nursery
35351 East Carmel Valley Road
Carmel Valley CA 93924
(831) 659-2830
www.ranacreeknursery.com

Coordination with the restoration nursery or seed supplier should occur during the restoration planning phase, at least one year in advance of restoration implementation, so that the nursery has ample lead time to secure sufficient quantities of seeds from near the Project area. Based on the revegetation schedule for hydroseed application, this coordination should occur in October-November 2024 (see Table 4-1).

Hydroseed Application

Hydroseeding will be used to restore vegetation along the Canal riparian banks and adjacent coastal scrub uplands and will occur no earlier than October 15 after soil preparation is complete, (or the onset of the first substantial rain event), and no later than March 1, or as directed by the Restoration Monitor.

The seed mix will consist of seed that is fresh and clean, according to the seed mix in Table 4-1. All seeds will be in conformance with the California State Seed law of the Department of Agriculture. Each seed bag will be delivered to the site sealed and clearly marked as to species, purity, percent germination, dealer's guarantee and testing dates. In addition, the container will be labeled to clearly reflect the amount of Pure Live Seed (PLS) contained.

The seed mix will be mixed with a hydromulch for application. The hydromulch will consist of the components described below. A fertilizer is not recommended with this mix due to the proximity of the hydroseeded area to the open waters of the Canal.

Soil Stabilizer

The soil stabilizing emulsion will be:

- A concentrated, biodegradable, organic derivative of corn, plantain or other organic material that forms a clear plastic film upon drying and allows water and air to penetrate
- Nontoxic to plant and animal life, non-corrosive, non-crystalline and non-staining to concrete or painted surfaces. The material will be registered with and licensed by the State of California, Department of Agriculture, as an "auxiliary soil chemical"
- Miscible with all available water at the time for mixing and application
- As manufactured by or equivalent to: Sentinel, Ecology Control M-Binder, AZ-TAC

Fiber

Fiber should be of the virgin wood cellulose type and should be commercially available and produced from virgin wood fiber. Fiber should be of such character that the fiber will disperse into a uniform slurry when mixed with water. Fiber should be free from noxious weeds and seeds, mold, pests, pathogens, and other deleterious materials. Fiber will not contain any growth or germination inhibiting substances. The mulch slurry will be colored with a nontoxic water-soluble green dye to aid in uniform application. Paper mulch will not be used.

Water

Water will be used in sufficient quantity to provide complete and homogeneous mix of slurry components and to facilitate application without run-off.

4.3.3 Fort Funston Dunes

Seed Material

The Fort Funston dune restoration and compensatory mitigation areas will be broadcast seeded with a custom seed mix of local coastal dune species that have proven successful in previous park restoration efforts. The anticipated seed mix for the Fort Funston dune restoration and compensatory mitigation areas is provided in **Table 4-3** and will consist only of local genetic stock. This seed mix should be considered preliminary and will need to be approved by the National Park Service.

TABLE 4-3
FORT FUNSTON DUNES SEED MIX

Scientific Name	Common Name
Acmispon strigosus	strigose bird's-foot-trefoil
Ambrosia chamissonis	silver beachweed
Baccharis pilularis ssp. consanguinea	prostrate coyote brush
Cardionema ramosissimum	sandmat
Camissoniopsis cheiranthifolia ssp. cheiranthifolia	beach evening-primrose
Ericameria ericoides	mock heather
Erigeron glaucus	seaside daisy
Eriogonum latifolium	coast buckwheat
Festuca rubra	red fescue
Fragaria chiloensis	beach strawberry
Lupinus bicolor	miniature lupine
Lupinus chamissonis	silver dune lupine

The source of the seeds will be coordinated with and approved by the National Park Service and consist only of local genetic stock. Because of the consistency in dune vegetation within San Francisco, Marin, and San Mateo counties, seed/plant suppliers with sources harvested within these counties will be used. Outside suppliers listed in Section 4.3.2 may be utilized, or more local supplier such as the Parks Conservancy may be utilized.

Coordination with the restoration nursery or seed supplier should occur during the restoration planning phase, at least one year in advance of restoration implementation, so that the nursery has ample lead time to secure sufficient quantities of seeds from near the Project area. Based on the revegetation schedule for broadcast seed application, this coordination should occur in October-November 2026 (see Table 4-1).

Broadcast Seed Application

Seeds of native coastal dune species will be broadcast in the restoration and mitigation areas. Seeds can be broadcast by hand or by mechanical means (e.g., using a hopper with a material regulating system in the bottom that feeds seed at a given rate either onto a spinner or directly onto the soil). Broadcasting will meet the following specifications:

- Half the seed will be spread in one direction and the other half will spread in the other direction (i.e., first east-west or horizontally and then north-south or vertically)
- Broadcast seed will be raked, harrowed, chain dragged, or tracked into the soil as feasible to enhance seed to soil contact

4.3.4 Avalon Canyon Coastal Scrub

Hydroseed Material

The Avalon Canyon restoration/mitigation areas will be hydroseeded with a custom seed mix of native, low-growing shrub and herbaceous species common to coastal scrub covered canyons along the coast. The anticipated seed mix for the Avalon Canyon restoration and mitigation areas is provided in **Table 4-4**.

TABLE 4-4
AVALON CANYON COASTAL SCRUB SEED MIX

Scientific Name	Common Name	Percent of Seed Mix	Approximate Number of Pure Live Seeds (pounds per acre)
Artemisia californica	California sage	15	1.5
Baccharis pilularis ssp. pilularis	Coyote brush	15	0.25
Diplacus aurantiacus	Sticky monkeyflower	25	0.5
Eriophyllum staechadifolium	Seaside wooly sunflower	25	5.0
Salvia mellifera	Black sage	10	5
Scrophularia californica	California bee plant	10	2.0

Hydroseed Application

Hydroseeding will be used to restore vegetation Avalon Canyon and will occur no earlier than October 15 after soil preparation is complete, (or the onset of the first substantial rain event), and no later than March 1, or as directed by the Restoration Monitor (planned for January-February 2025).

The seed mix will consist of seed that is fresh and clean, according to the seed mix in Table 4-4. All seeds will be in conformance with the California State Seed law of the Department of Agriculture. Each seed bag will be delivered to the site sealed and clearly marked as to species, purity, percent germination, dealer's guarantee and testing dates. In addition, the container will be labeled to clearly reflect the amount of PLS contained.

The seed mix will be mixed with a hydromulch for application. The hydromulch will consist of soil stabilizer, fiber and water, as described in Section 4.3.2 for the Canal hydroseeded areas. A fertilizer may be incorporated into the hydroseed mix for Avalon Canyon as it is not restricted by the presence of surface water (Canal).

4.4 Site Preparation

Upon construction completion, the temporarily disturbed areas will be contoured according to similar pre-Project site topography and slopes will be compacted to reduce the potential for erosion, but to remain suitable for planting. Any additional lands identified for mitigation will be cleared of existing vegetation. Substantial earthwork is not anticipated for any of the additional mitigation areas under this Plan.

The Restoration Monitor will verify any recommended soil preparation work prior to initiation of seeding or planting at each site, such as additional topsoil material.

Erosion control blankets, hydromulch, straw wattles or other appropriate erosion and sediment control methods will be used as necessary on slopes to reduce stormwater runoff and surface erosion, and to promote vegetation establishment. Erosion and sediment control mats and blankets and straw wattles will be composed entirely of biodegradable materials such as jute, coconut fiber, or sterile, weed-free straw and not contain any plastic monofilament mesh. These materials will break down over time once the restoration areas are fully established. Erosion and sediment controls will be installed pursuant to the Project Storm Water Pollution Prevention Plan (SWPPP).

4.5 Vegetative Plant Material Harvest and Planting

4.5.1 Lake Merced

Because of the seasonal timing of the impact and scheduled construction duration at individual sites, it will be necessary to harvest vegetative plant material from nearby populations at Lake Merced and other locations in the Project vicinity rather than from the temporary impact areas (see Table 4-1 for the revegetation schedule). Locating and accessing harvest locations could be greatly assisted through coordination with the San Francisco Recreation and Parks Department, as they have experience restoring native plant communities in the Project vicinity. Furthermore, the San Francisco Recreation and Parks Department oversees recreational uses at Lake Merced and could provide valuable information on harvesting in areas of heavy recreational use.

Table 4-5 identifies the number of wetland and riparian plants and the spacing needed to restore anticipated temporary impacts to freshwater marsh and arroyo willow riparian wetlands at the Project sites along the Lake Merced shoreline.

TABLE 4-5
ANTICIPATED VEGETATIVE PLANTING UNITS FOR TEMPORARY IMPACT WETLAND AND RIPARIAN ONSITE RESTORATION AT LAKE MERCED

	Spacing (ft)	Number of planting units[1]
California bulrush	4	1,162
Swamp knotweed	3	315
Arroyo willow	5	2,406

NOTE:
1 The estimated number of planting units is based on the total area of temporary impact for each wetland type, divided by the spacing.

Wetland Plant Harvest and Planting Methods

Planting units will consist of approximately 2-3 above-ground stems and their attached rhizome mass for swamp knotweed. California bulrush planting units will consist of one above-ground stem and attached rhizome mass. This amount of material is considered to be the smallest unit sufficient for establishment and will also minimize disturbance to the harvest populations.

When harvesting from intact wetland communities in the Lake Merced vicinity, it is imperative to minimize the harvesting disturbance by collecting only a few planting units from a large area, and from several populations. Foot traffic and trampling disturbance should be minimized to the extent feasible and vehicles should remain on roads or in upland access sites.

The following methods are recommended for the harvest and planting of wetland plant material:

- Stems and attached root masses can be dug up by hand using a shovel and placed in a bucket or wheelbarrow to transport to a tarp-lined bed of a truck or trailer.
- Soil from the harvest site will be lightly brushed off the below-ground material immediately after it is dug up, to the extent feasible, to reduce the amount of soil removed from the harvest site. California bulrush and swamp knotweed plants will not be harvested from the shoreline adjacent to the former Pacific Rod and Gun Club site due to soil contamination in shoreline wetlands subject to CWA 404 jurisdiction.
- Planting material will be kept wet so that it does not dry out and become stressed in transport or during short-term storage at the planting site.
- The Restoration Monitor will place colored pin flags in the planting areas to designate where planting units of each species should be planted so that the arrangement is random (not a grid) and the plant spacing follows the planting design.
- Planting holes will be dug to a depth and width approximately one and a half times the size of the rhizome mass so that the hole will easily accommodate the below ground structures and can be loosely filled in with topsoil material and lightly firmed in place.
- Each plant will be thoroughly watered in.

Arroyo Willow Harvest and Planting Methods

Arroyo willow stakes (stem cuttings) will be harvested from willow trees adjacent to the temporary impact areas and from nearby locations at Lake Merced as needed, and in coordination with the San Francisco Recreation and Parks Department. The guidelines below will help to ensure that willow stakes are properly harvested, stored, and installed to maximize their chance of establishment success.

- Cuttings of willow are best made during the winter when plants are dormant (December).
- Care should be taken to harvest lightly from a large area and from multiple individuals so that genetic diversity remains high at the planting site, and damage to source plants is avoided.
- Stakes should be harvested from branches at least two years of age, measuring at least ¾ inch in diameter and cut to a length of 4 feet. Marking the basal end of each stake as it is harvested (e.g., with a diagonal rather than a horizontal cut) will help to avoid confusion about which

end to plant when stakes are installed. The apical bud and side branches should be removed at the time of harvest.

- Soaking willow stakes in water for 24 hours prior to planting will improve their ability to root once they are planted.
- Willow stakes should be inserted into 3-foot-deep augured holes. Deeper holes can be used if the depth to groundwater is greater than 3 feet in the wet season though stakes longer than 4 feet would be required in this case. Stakes should be installed so that 1 ft remains above the ground level.
- Once the stake is installed, the hole should be filled with a mixture of soil and water. Once the mixture settles, more can be added until the hole is completely filled with soil. This process will create a good contact zone between the stake and the soil to promote immediate rooting.
- If the soil is dry at the time of installation, each stake should be watered slowly with one gallon of water, ensuring that all water percolates into the soil and no runoff occurs.

4.5.2 Canal

Tree Planting Methods

The Project will plant replacement trees at a 1:1 ratio (removed : replaced) within the Canal coastal scrub uplands restoration area for trees removed from this area during construction (estimated at 51 trees removed/replaced). Tree plantings will primarily be coast live oak, with other oak woodland tree species appropriate for the area (such as California buckeye or California bay laurel). Relative quantities by species are dependent on the availability of plants and associated materials. New tree plantings should be nursery-grown trees in 15-gallon containers. Container stock must be obtained from a local nursery (i.e., greater San Francisco Bay Area) that can certify implementation of best management practices to reduce chances of pest and pathogen contamination within their nursery. Container plantings will be installed during late fall or early winter of the restoration year.

Tree plantings should be irrigated regularly to ensure that individuals do not dry out during the establishment period. Irrigation frequency and duration will be dependent on the weather conditions and the recommendations of the Restoration Monitor. Watering may be provided through an irrigation system tied into an existing water line, if possible. A drip irrigation system is the preferred method. A water truck, stationary tank, or other method could be used if temporary irrigation is not incorporated into the restoration phase of the Project.

4.5.3 Fort Funston

Dune Planting Methods

To compliment broadcast seeding within the Fort Funston dune restoration areas, some shrub species will be installed as container plants. Species of shrub plantings, quantities, and spacing recommended in **Table 4-6**, are based on approximate current conditions in both the main (tunnel) staging area and the blufftop staging area. In the main staging area, mock heather and silver dune lupine will be planted to fill areas of temporary impact, at a minimum spacing of 20 feet on center. Coyote brush will be planted at the blufftop impact area, at a minimum spacing of 15 feet on center. Relative quantities by species are dependent on the availability of plants and associated materials.

TABLE 4-6
ANTICIPATED VEGETATIVE PLANTING UNITS FOR TEMPORARY IMPACT DUNE RESTORATION AT FORT FUNSTON

Species	Spacing (ft)	Number of planting units[1]
mock heather (*Ericameria ericoides*)	20	75
silver dune lupine (*Lupinus chamissonis*)	20	75
prostrate coyote brush (*Baccharis pilularis ssp. consanguinea*)	15	8

NOTE:
1 The estimated number of planting units is based on the total area of temporary impact the dune habitat type, divided by the spacing.

Shrub plantings will be installed by a qualified restoration professional with experience planting container stock in sand dunes and in coordination with the National Park Service. All necessary precautions will be taken to ensure best chances of survival by plantings in this unique substrate. Plantings should be irrigated regularly to ensure that individuals do not dry out during establishment with the use of a water truck or stationary tank. Irrigation frequency and duration will be dependent on the weather conditions and the recommendations of the Restoration Monitor. Restoration planting areas at Fort Funston will exclude pedestrians and dogs with the installation of fencing and signage consistent with other restoration areas established within Fort Funston.

4.6 Best Management Practices

Steep slopes of the Project area on the Lake Merced shoreline and along the Canal riparian banks could become unstable and lead to surface erosion or sedimentation. Erosion control mats, blankets, straw wattles or other appropriate erosion and sediment control methods will be used on steep slopes and disturbed soils to protect soil, minimize erosion, and to promote vegetation establishment.

At the discretion of the Restoration Monitor, additional erosion control measures will be installed to protect the restoration areas. If areas of erosion are observed in the restoration areas during the monitoring period following the completion of soil remediation activities, erosion and sediment controls will be implemented as remedial measures (discussed in Section 5.3).

4.7 Invasive Weed and Non-native Plant Management

For the purposes of this Project, invasive weeds include non-native, invasive species (including subspecies and varieties) that have an overall rating of high or moderate as listed by the California Invasive Plant Council, Central West Region (Cal-IPC), or identified as highly invasive (Tier 1) or moderately invasive (Tier 2) non-native species listed by the SFBRWQCB for wetland/creek areas (SFBRWQCB, 2006).

As already discussed, the presence of invasive weeds within the Project impact areas at Lake Merced is low, with vegetation dominated by native wetland and riparian plants (see Section 2.3.1).

Vegetation adjacent to the Canal is composed largely of non-native species, some of which are invasive. The southwest side of the Canal abuts a golf course, and many of the horticultural species associated with the golf course landscaping overhang or grow up to the bank of the Canal. These include non-native oleander (*Nerium oleander*), privet (*Ligustrum* sp.), nasturtium (*Tropaeolum majus*), and Eucalyptus (*Eucalyptus* spp.) among other horticultural trees and shrubs. The northeast side of the Canal between the channel and John Muir Drive is dominated by non-native and invasive species. Dominant non-native species include rattlesnake grass (*Briza maxima*), soft chess (*Bromus hordeaceus*), brome fescue (*Festuca bromoides*), hare's tail grass (*Lagurus ovatus*), English plantain (*Plantago lanceolata*), and wild radish (*Raphanus sativus*). Invasive species that are prolific in this area include cape ivy (*Delairea odorata*), slender wild oat (*Avena barbata*), poison hemlock (*Conium maculatum*), rip-gut brome (*Bromus diandrus*), red brome (*Bromus rubens*), ice plant (*Carpobrotus chilensis*), Himalayan blackberry (*Rubus armeniacus*), and greater periwinkle (*Vinca major*). These non-native and invasive species are ubiquitous throughout the surrounding area and are part of the pre-Project, baseline condition described in the Project EIR/EIS (ESA, 2016; ESA, 2017). In an effort to improve the habitat conditions at this location, non-native non-invasive species along the Canal will be monitored and managed alongside invasive weeds using the same monitoring and management methods.

The dominant invasive species within the Fort Funston staging areas is ice plant. The blufftop staging area is covered in a dense stand of ice plant. The staging area at Fort Funston has occasional patches of ice plant, and scattered invasive grasses such as rip-gut brome and slender wild oat, but overall cover of invasive plants in this area is low. At Avalon Canyon, invasive pampas grass (*Cortaderia jubata*) is prevalent along the paved access road.

Invasive weeds and non-native plants will be controlled in all restoration areas during the established monitoring period(s) utilizing integrated approaches as directed by the Restoration Monitor. Control methods could include mechanical methods such as hand pulling or weed whacking/bruscutting. Herbicide use will be prohibited in wetland and riparian restoration areas due to the proximity of these locations to water bodies.

Invasive weeds and non-native plants will be controlled in all restoration areas with the goal of preventing seed production and other methods of spread. Monitoring during the early part of the growing season (February-April) is critical for identifying invasive weed and non-native plant seedlings and planning maintenance activities (see Sections 5.1 and 5.2 for invasive weed monitoring requirements). Invasive weeds and non-native plants containing seed or other reproductive propagules (vegetative reproductive structures such as rhizomes, tubers, stem fragements etc, capable of growing new plants) will be carefully collected in trash bags or closed vehicles and disposed of at a landfill in such a way so as not to spread weed seeds or propagules.

A preliminary schedule of invasive weed and non-native plant maintenance will include maintenance at least twice per year, once in the spring and once in the summer. Based on monitoring results and site conditions the schedule can be adjusted by the Restoration Monitor to accommodate more or fewer maintenance activities, as needed.

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SECTION 5
Monitoring Methods and Reporting

5.1 Monitoring Schedule

Restoration monitoring will be carried out for a minimum of five years in restored Lake Merced freshwater marsh wetlands, arroyo willow riparian wetlands, the Canal riparian banks and adjacent uplands, Fort Funston restoration and mitigation areas, and Avalon Canyon restoration and mitigation areas to observe and document the performance of the revegetated areas and to guide maintenance activities. Restored arroyo willow riparian wetlands have established performance standards through year ten, but may achieve these metrics earlier than outlined in the monitoring schedule. If the performance standards are met prior to year ten the monitoring requirement will be considered complete. Mitigation tree plantings will be monitored annually for ten years.

Monitoring and maintenance needs during the initial establishment period (years 1-3) are expected to be greater than monitoring and maintenance needs for more established plants (years 4 and 5 and beyond), particularly if early maintenance actions including weed management, and erosion/sediment control replacements during the first two years are successful.

Table 5-1 identifies the timing of key annual monitoring events for revegetated areas for each year along with the primary monitoring objectives of each event. General Site Assessments to verify plant health, note presence of invasive weeds, check efficacy of erosion/sediment controls and other conditions that may affect the success of restoration are discussed below in Section 5.2.4. **Table 5-2** identifies the monitoring schedule for mitigation tree plantings.

Monitoring mitigation tree plantings will occur twice a year for the first three years, then once a year for years four through ten. During the first three years, spring monitoring will consist of a qualitative site assessment and tree support maintenance. Monitoring survivorship will occur in the fall. Table 5-2 identifies the monitoring schedule for mitigation tree plantings.

TABLE 5-1
ANNUAL VEGETATIVE MONITORING SCHEDULE

Schedule	Objective
Year 1	
February	Invasive weed and non-native plant seedling monitoring,[1] inspect soil stability
May	Annual vegetation monitoring- record survivorship and vegetation cover
July	Assess plant health and maintenance needs
November	Assess plant health and soil stability
Year 2	
February	Invasive weed and non-native plant seedling monitoring,[1]inspect soil stability
May	Annual vegetation monitoring- record survivorship and vegetation cover
July	Assess plant health and maintenance needs
November	Assess plant health and soil stability
Year 3	
February	Invasive weed and non-native plant seedling monitoring[1]
May	Annual vegetation monitoring- record vegetation cover
July	Assess plant health and maintenance needs
November	Assess plant health and soil stability
Year 4	
February	Invasive weed and non-native plant seedling monitoring[1]
May	Annual vegetation monitoring- record vegetation cover
July	Assess plant health and soil stability
November	Assess plant health and soil stability
Year 5	
February	Invasive weed and non-native plant seedling monitoring[1]
May	Annual vegetation monitoring record vegetation cover
July	Assess plant health and soil stability
November	Assess plant health and soil stability
Years 7 & 10	
May	Vegetation monitoring of arroyo willow riparian habitat- record vegetation cover Monitor and treat invasive weeds and non-native plants

NOTE:
1 The performance standard for invasive weed cover is less than 10 percent in all years.

TABLE 5-2
TREE MONITORING SCHEDULE

Monitoring Activity	Timing	Frequency / Duration
Survivorship	Fall	Annually for 10 years
Qualitative Assessment	Spring Fall	Annually (1 – 3 years) Annually for 10 years

5.2 Monitoring Methods

5.2.1 Ground Vegetation

Monitoring of restored areas will include assessing plant survival and vegetative cover, photo documentation, general site assessments, and analysis of the results.

Prior to initiation of monitoring, the Restoration Monitor will also select and document appropriate nearby reference sites for each of the different impacted habitat types, in order to comparatively assess success of the restored areas. Freshwater marsh and riparian shoreline habitats adjacent to restored areas are appropriate references for evaluating restoration success. Transects can be established within adjacent habitats to the restored areas and cover data collected during monitoring events to serve as benchmarks for restoration site performance.

Survivorship

Lake Merced

Percent survival will be determined by counting individuals of each species and comparing the counts to the number of live vegetative propagules or cuttings originally installed for that species in freshwater marsh and arroyo willow riparian revegetation areas. A minimum survival rate of 70 percent for all installed plants is required for the first two years in freshwater marsh wetlands and for the first year for arroyo willow riparian wetlands. If survival drops below this level, replacement plants will be installed in the following fall or winter unless there is substantial natural recruitment of wetland plants (as documented by the vegetative cover monitoring in year 2). Replacement plants will be monitored for at least 2 years to ensure that they achieve the 70 percent survivorship standard. A detailed description of performance standards is presented in Section 2.3, and outlined in Table 2-1, 2-2, 2-3, 2-4 and 2-5.

Fort Funston

Percent survival will be determined by counting individuals of each species and comparing the counts of the number of shrubs originally installed for that species in the dune revegetation areas. A minimum survival rate of 50 percent for all installed plants is required for the first two years. Naturally recruited shrubs of the target species will be included in overall survival counts. If survival drops below 50 percent of the number planted, replacement plants will be installed the following fall or winter. Replacement plants will be monitored for at least 2 years to ensure that they achieve the 50 percent survivorship standard. A detailed description of performance standards is presented in Section 2.3, and outlined in Table 2-1, 2-2, 2-3, 2-4 and 2-5.

Vegetative Cover

Due to the differences in plant growth form and community structure of the restoration types included in this Plan, different vegetation cover monitoring methods are proposed for each area.

Lake Merced

Freshwater Marsh Wetlands

Fixed, permanent restoration transects, will be established at a minimum of two locations, parallel to the shoreline (where possible), within the planted freshwater marsh areas. Two reference transects, to be located in areas nearby but outside of the temporary disturbance areas, will also be established during or just prior to the initial monitoring event, to serve as contemporary and appropriate reference sites for comparison with restored sites at the end of the monitoring period. Transect length may vary depending on the size and shape of the planting area, though a good target is 25-50 ft (5-15 meters[m]). Based on the total length of the transect, 3-6 plot locations should be identified for each transect. Reference transects should be of similar length, and with similar plot numbers/spacing. Each plot will be one square meter in size ($1m^2$), and the location of plots along the transect should be randomized. Plot orientation to the transect (shoreline or interior side) should alternate as planting area space will allow. The same plots should be monitored by the Restoration Monitor annually using visual estimations of plant cover (see pages 10-13 of the California Native Plant Society's (CNPS) Relevé Protocol for estimating vegetation cover, [CNPS, 2000]). Data will be collected from the nearby reference transects in the first and final year of monitoring, to serve as a comparative measure of performance for restored sites. All plant species observed should be recorded, along with their total cover value. Alternatively, cover can be recorded in cover classes, as determined by the Restoration Monitor. With cover information for each species, the data can later be summarized to provide the total vegetation cover, total cover of native species, total cover of invasive weeds, or any other classification that may be important for assessing the performance of the restored freshwater marsh. Care should be taken to not stand or walk through the plots so that cover estimates accurately reflect existing conditions from year to year.

Arroyo Willow Riparian Wetlands

The line-intercept sampling method is a method commonly used for assessing woody perennial vegetation that has a large canopy at maturity. This method measures the distance of the canopy of each plant, projected downwards vertically, as the canopy intercepts a transect tape. All distances for each individual species are then added together. Herbaceous understory vegetation will also be recorded within the transect and will be included in the total cover value. The percent cover for a species is the cumulative length of intercepts for that species divided by the length of the transect, multiplied by 100.

A minimum of three restoration transects should be established in the arroyo willow riparian restoration areas (distributed throughout the site; one per Project component impact location). In addition, at least two reference transects located nearby but outside of the temporary disturbance areas, one along the South Lake shoreline and one along the Impound Lake shoreline, should be established for comparison with restored sites at the end of the monitoring period. Depending on the size and shape of the planting areas, restoration transect length can range from 25-50 ft (5-15 m). Reference transects should be of similar length. Data will be collected from the nearby reference transects in the first and final year of monitoring to serve as a comparative measure of performance for restored sites.

Vista Grande Canal

Riparian Banks and Adjacent Uplands

A minimum of three fixed, permanent restoration transects will be established within the hydroseeded revegetation areas along the Canal. One reference transect, to be located along the Canal in the area nearby but outside of the disturbance areas, will also be established during or just prior to the initial monitoring event, to serve as a contemporary reference site for comparison with restored sites at the end of the monitoring period; however, it should be noted that at this location, existing conditions include low percent cover and high percent non-native/invasive species. As such, the restoration areas' performance is expected to far exceed the observed conditions at the nearby referfence transects. Transect length may vary depending on the transect location within the revegetation area and monitoirng method (25-50 ft is a good target). The reference transect should be of similar length if possible. Either the square meter plot or line-intercept method described above may be used at both the restoration and reference sites, as appropriate and detertmined by the Restoration Monitor, based on the final seed mix composition. The same transects/plots should be monitored by the Restoration Monitor annually; data from the nearby reference transect should be collected in the first and final year of monitoring, to serve as a comparative measure of performance for the restored sites. Cover data can be summarized to provide the total vegetation cover, total cover of native species, total cover of invasive weeds, or any other classification that may be important for assessing the performance of the restored Canal riparian banks. Care should be taken to not stand or walk through the plots so that cover estimates accurately reflect existing conditions from year to year.

Fort Funston

Vegetative cover within the tunnel staging area is naturally patchy and can shift from year to year due to sand movement characteristic of dune habitats. The use of drones to document vegetative cover through aerial imagery is proposed for this restoration area instead of more traditional transect methods already described. While the exact methods of drone photography may evolve from year to year due to advances in technology, there are several factors that can be held constant to ensure the integrity of a comparative assessment of vegetative cover and habitat conditions over time. The following measures will be implemented during each drone survey:

- Drone equipment will contain an internal GPS system that captures altitude, speed, and elevation of every image taken;
- Flight path transects and imagery sequence will capture the entire site at several elevations, such as 150 ft, 100 ft, and 50 ft (to aid analysis at various scales) and capture at least 85 to 90 percent imagery overlap between photographs;
- Surveyed surface area will extend at least 100 ft beyond the restoration area boundary to capture any expansion of vegetation plantings and to avoid any image warping along the edges during the editing phase; and
- A camera with Red, Green, Blue (RGB) and Infrared sensors (near-IR) will be used.

Exact methods of drone imagery capture may vary due to field circumstances at the time of implementation. The first annual monitoring report for this restoration area will document the methods implemented such that future surveys are conducted to the same specifications.

Data and imagery analysis will include georeferencing images that have been stitched together into a digital surface model (DSM) to be then further analyzed. Using geographic information system (GIS) and programming software, vegetative cover can be classified to report on the restoration progress.

The drone flight and imagery will be coupled with a pedestrian survey to document species richness and estimate their relative composition.

If a drone flight is not feasible, a pedestrian survey will document species richness and map vegetated areas (delineated from the non-vegetated sand) using a handheld GPS unit. Vegetative cover within the restoration area will be quantified using GIS software. A similar exercise informed by a pedestrian survey will be used to assess vegetative cover of the restored blufftop staging area.

Avalon Canyon

Vegetative cover of the coastal scrub restoration area at Avalon Canyon may be monitored in one of two ways: using a transect or through a visual assessment of the area as a whole. Due to the expected size of this area, monitoring with multiple restoration transects will not be necessary. The actual impact area may be large enough to fit one permanent, fixed monitoring transect of 25-50 ft during the initial monitoring event. Either the square meter plot or line-intercept method (described above) may be used, as appropriate and detertmined by the Restoration Monitor, based on the final seed mix composition. A nearby reference site will be established in similar vegetation during the first year of monitoring from which quantitative data will be compared with restoration area data to track performance over time. The same transect/plots established within the restoration area will be monitored by the Restoration Monitor annually; data from the nearby reference transect/site will be collected in the first and final year of monitoring, to serve as a comparative measure of performance for the restored site. Cover data will be summarized to provide the total vegetation cover, total cover of native species, and total cover of invasive weeds. Care should be taken to not stand or walk through the plots so that cover estimates accurately reflect existing conditions from year to year.

Alternatively, the size of the coastal scrub restoration area allows for a visual cover survey of the entire site. The restoration monitor will conduct a pedestrian survey of restored area and estimate the percent cover of vegetation within the entire site. Cover data will be summarized to provide the total vegetation cover, total cover of native species (per species), and total cover of invasive weeds.

5.2.2 Trees

Survivorship

Percent survival will be determined by counting individuals of each tree species and comparing the counts to the numbers originally planted for that species. Survival data will be collected at approximately the same time during each successive fall on an annual basis during the ten-year monitoring period. Natural recruitment of native trees, if observed onsite, will also be noted and counted towards survivorship

Health, Vigor, and Height

A qualitative assessment of health and vigor of trees planted in the coastal scrub woodland restoration area will be performed during the annual monitoring and scored per the following criteria (**Table 5-3**, below). Health and vigor assessment is a useful diagnostic tool for identifying issues with the plantings and determining the need for any potential remedial actions. Height of planted trees and shrubs will be measured once annually during the ten-year monitoring period.

TABLE 5-3
QUALITATIVE SCORE FOR ASSESSING THE HEALTH AND VIGOR OF TREES

Score	Description of Score
Excellent	Plant has substantial new growth; no evidence of stress; minor pest or pathogen damage may be present, no chlorotic leaves, no or very minor herbivory (browse).
Good	Plant has new growth; some evidence of stress; pest or pathogen damage present, few chlorotic leaves (>5%), minor evidence of herbivory (browse).
Fair	Plant has only minor new growth; moderate level of stress; high levels of pest or pathogen damage, some chlorotic leaves (>10%), some herbivory damage (few snapped leaves, stems, wear marks etc.).
Poor	Plant shows little to no signs of new growth; high level of stress; high levels of pest or pathogen damage, many chlorotic leaves (>30%), severe herbivory damage (massive forage damage, main stems/leaves stripped etc.).

Tree Function and Habitat Value

A qualitative assessment of tree function and habitat value of the restored coastal scrub woodland will be performed during the annual monitoring event(s). Observations of wildlife use during the monitoring visit(s) throughout the year will inform the discussion in the annual report. A comparison pre-project tree function and habitat value with trees in the restored upland area will be included in the final monitoring report.

5.2.3 Photo Documentation

Permanent photo-monitoring points (minimum of 10 – with at least one for each habitat type in each impact location at South Lake, Impound Lake, the Canal, Fort Funston, and Avalon Canyon) should be established in the restoration areas prior to Project construction, to document pre-Project conditions. The photo-monitoring points should be recorded with a GPS to provide easy relocation during annual monitoring events, and a map showing the location of the points with photo direction should be included in the annual monitoring reports. Photos from the photo-monitoring locations showing the pre-construction and post-planting condition should accompany the first year monitoring report. Photos should be taken at these same points annually to document landscape-level changes over time in the revegetation areas. Additional photo-monitoirng points may be added post-construction to further document restoration conditions. Photos from each monitoring event can be qualitatively compared with the baseline conditions and previous years. Photos of nearby reference site transects should also be taken in the first and final year of monitoring.

5.2.4 General Site Assessments

A General Site Assessment is a simple way to make observations of site conditions. A large variety of conditions can be assessed including: habitat characteristics (e.g., increase/decrease/ new occurrence of weeds, general health and productivity of the restored vegetation communities), observation of wildlife species and wildlife use of the restoration areas, human disturbances, trash, and natural disturbances such as fire, wind damage, and drought, which may all have an impact on the success of management actions. Observations should be recorded in a field notebook or standardized data form in the same manner during each site visit.

General Site Assessments, in addition to photo documentation, will also be used to assess any erosion or slope instability during the monitoring period. The Restoration Monitor should record observations of slope failure, irregular sediment transport or deposition, and any changes along the lake shoreline, Canal slopes, Fort Funston dune topography, and Avalon Canyon restoration area.

General Site Assessments are recommended quarterly throughout the monitoring period, though they can be conducted more or less frequently depending on site performance (e.g., intended species establishment, health and vigor and low presence of invasive species).

5.2.5 Analysis of Results

Data should be collected in the field according to the methods described in Section 5.2. This includes both quantitative and qualitative data that will be recorded on datasheets, processed, and saved in a place that can be easily retrieved for summarizing results and for comparison during the next monitoring event. To evaluate whether revegetation goals of the Plan are being met, it is necessary to compare the monitoring data and results from the current and previous years with the performance standards (which are based on pre-project reference information observed at the project site by ESA botanists and restoration ecologists between 2012 and 2021), as well as with nearby reference site information, and interpret the trends based on professional judgment.

5.3 Remedial Measures

If General Site Assessments or annual monitoring indicate that site maintenance is needed or performance standards are not being met, remedial measures (i.e., adaptive management) will be implemented. Remedial measures will be directed by the Restoration Monitor and may include additional weed control, trash and litter control, repair or installation of erosion/sediment controls, and/or supplemental seeding or planting.

The results of annual monitoring and General Site Assessments will provide a basis for determining the need for possible remedial measures based on professional judgment of the Restoration Monitor. If restored freshwater marsh wetlands, arroyo willow riparian wetlands, the Canal riparian banks and adjacent uplands (including mitigation trees), Fort Funston dunes, or Avalon Canyon coastal scrub restoration areas do not meet the final performance standards (years five and ten) indicating that Project restoration may be unsuccessful in some way, a revised or supplemental compensation plan shall be prepared and submitted to the Commission within 90 days of submittal of the final monitoring report. The revised or supplemental compensation plan shall demonstrate how the deficient aspects of the mitigation areas associated with construction impacts can be explained or corrected to ensure that Project compensatory mitigation requirements for construction impacts are fulfilled, and shall be implemented upon approval by the Commission.

5.4 Reporting

5.4.1 Annual Report

Annual monitoring reports will be submitted to the Commission by January 31st of the year immediately following the monitoring year, for the (minimum) five year monitoring period, and will cover the Lake Merced freshwater marsh and arroyo willow riparian wetlands, Canal revegetation, Fort Funston restoration, and Avalon Canyon restoration. Monitoring reports documenting arroyo willow riparian habitat at Lake Merced will continue to be prepared and submitted to the Commission in years 7 and 10 (or until performance standards are met). A report documenting performance if mitigation tree plantings will be submitted annually for ten years.

The first year report will summarize the baseline information as well as the first year monitoring results. Baseline information must include 'as-built' plans, drawings, or maps, that accurately depict what was planted and where. Thereafter, annual reports will consist of a summary of information contained in previous reports, as well as a presentation of the current year's results and discussion of any comparisons between years or trends noted.

Annual reports will include, at the minimum, the following information:

- Summary description of the monitoring methods, including data collection and analysis;
- An overview of the restoration effort, including a general discussion of site conditions, changes since previous report, and quantitative comparisons (average growth by species and percentiles of cover and survival);
- Analysis of success in relation to performance standards;
- Color photographs of the revegetation areas taken from the photopoint locations;
- A map of the area with relevant features, habitats, and photopoints, and;
- A discussion of any adaptive management measures needed or undertaken (including invasive weed control, replanting, or erosion/sediment control measures).

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SECTION 6

Fulfillment of Compensatory Mitigation for Permanent Impacts: Re-establishment and Enhancement of Wetlands and Open Waters

This section outlines the proposed compensatory mitigation approach for permanent Project construction impacts on potential wetland-ESHA, in addition to mitigation acreage required beyond that which can be satisfied through on-site restoration of construction disturbance areas at South Lake and Impound Lake. As discussed in Section 3 (Table 3-3), the proposed approach accounts for the higher mitigation ratios for temporal loss of habitat per Commission guidance. This approach is adapted from the *Riparian and Wetland Restoration and Mitigation Monitoring Plan for the San Francisco Regional Water Quality Control Board Jurisdictional Resources* (RWRMMP; ESA, 2022b) prepared for and accepted by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). For a complete discussion of the Project's approach to mitigation for permanent impacts to waters of the State, please see the *Compensatory Mitigation Plan* (ESA, 2021b; **Appendix E**), also prepared for and accepted by the SFRWQCB. The *Compensatory Mitigation Plan* demonstrates that through the approach described herein, Project-generated mitigation for permanent impacts to waters of the State will greatly exceed the compensation acreage required, resulting in the generation of "excess" mitigation credits for both wetlands and open waters, as well as net overall increases in wetland and open water acreages as compared to current conditions.[17] Although the *Compensatory Mitigation Plan* is focused on waters of the State, the approach is relevant to the Commission's review of the Project, as it provides a basis for understanding the City's SFBRWQCB permit obligations, along with the rationale for the Project being viewed as self-mitigating. Notably, under the Project, the total cover of potential ESHA wetlands (collective) is predicted to increase under any of the WSE scenarios analyzed.

As discussed in Section 3.1, permanent impacts to one-parameter wetlands,[18] open waters, and riparian banks (identified as waters of the State) will result from the installation of several water control structures in Lake Merced, the conversion of a portion of the brick- and concrete-lined Vista Grande Canal[19] (an engineered trapezoidal channel) to a closed box culvert with a

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[17] On November 5, 2021, the SFBRWQCB confirmed via email to the Project team that the agency concurred with the compensatory mitigation proposal.

[18] One-parameter wetlands considered waters of the State are characterized by having either hydrology, hydric soils, or hydrophytic vegetation (as identified on the current USACE National Plant List), rather than wetlands containing all three parameters which would qualify as waters of the U.S.

[19] The state jurisdictional status of the Vista Grande Canal, a man-made canal constructed in uplands for stormwater control, is disputed by the project team. The Canal was determined federally non-jurisdictional pursuant to Section 404 of the Clean Water Act by the USACE in 2016. For the same reasons the Canal was determined not to be a

constructed treatment wetland atop it, and the modification of an existing Ocean Outlet structure and portion of the existing submarine outfall pipeline at the beach at Fort Funston (Pacific Ocean).[20] Additional impacts to arroyo willow wetlands from the construction disturbance area surrounding the Lake Merced outlet structure in Impound Lake are categorized as "permanent" according to the Commission's guidance because of the duration of disturbance to this habitat and temporal, functional loss to the ecosystem while it is unavailable for use as a mature arroyo willow thicket.

Implementation of the Project will result in a multitude of benefits, including, but not limited to flood control improvements, water quality improvements, recreational and access improvements, and a long-term restoration and increase in the managed water surface elevation (WSE) of Lake Merced. Additionally, Project operations will expand coastal freshwater marsh (wetlands) in the lake system which will continue to benefit local wildlife by providing valuable foraging and nesting habitat for passerines and waterfowl that occupy the lake. All of these benefits will directly or indirectly benefit aquatic resources, including their designated Beneficial Uses.[21] A more detailed discussion of the Project's Beneficial Uses is included in the *Compensatory Mitigation Plan*, provided as Appendix E (ESA, 2021b).

As a key part of the Project's purpose to improve water quality in Lake Merced, the Project provides for a long-term restoration and increase in WSE, which is predicted to result in the creation (or re-establishment[22]) of certain aquatic habitats (wetlands and open waters, each of which is regulated by the SFBRWQCB and the Commission). As introduced in Section 3.2, the composition of Lake Merced shoreline vegetation is expected to change in response to increased lake levels, with the predicted net change in shoreline wetlands expanding by between 2.04 and 3.41 acres. This Project-generated expansion of shoreline wetland and open water area will occur within the same watershed as the construction impacts. These habitat improvements are considered "on-site" mitigation activities – each will provide mitigation immediately adjacent to existing aquatic resources, and will predominantly provide "in-kind" mitigation for the impacted resources. As such, the benefits of the Project's operational WSE increase provides the type of mitigation that is generally preferred or prioritized under the USACE's 2008 Mitigation Rule[23] and that provides relevant benefits to the watershed as a whole. Based on this, the open waters and shoreline wetlands acreages at Lake Merced that will be re-established and enhanced through Project implementation are proposed to provide appropriate self-mitigation for permanent construction impacts of the Project on these resources, and to ensure the Project will not result in

"waters of the U.S." by the USACE, the City maintains that the Canal is similarly not a "waters of the State," but rather a non-natural, constructed in upland dry land, stormwater conveyance channel that is solely a component of the City's MS4 to link the underground storm system to the discharge outfall to the Pacific Ocean. Nonetheless, based on direction from Regional Water Board staff, the Canal is being treated as a "water of the State" for purposes of permitting and mitigation.

[20] However, as mentioned previously, the modification of the existing Ocean Outlet structure will result in a net removal of structures/fill in waters at the Pacific Ocean. (Despite some small areas of new permanent impact, larger areas of existing permanent structures/fill will be removed, with the "pulling back" of the structure relative to the shoreline).

[21] Beneficial Uses are designated by waterbody in the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan).

[22] Based on historic higher WSEs and the understanding that similar habitats existed with those higher historic WSEs.

[23] Department of the Army, Corps of Engineers: Compensatory Mitigation for Losses of Aquatic Resources; Final Rule (40 CFR Part 230, as published in the Federal Register on April 10, 2008).

a net loss of aquatic resource acreages or functions, when a 1:1 mitigation ratio is applied for resources impacted : mitigation created. In addition to these net acreage gains and functional improvements that will be generated by the Project, the Project will restore and enhance coastal dune habitat at Fort Funston, restore and enhance coastal scrub habitat within Avalon Canyon, and construct new treatment wetlands adjacent to the Canal for providing numerous watershed benefits including water quality improvement.

The acreage of aquatic habitats predicted to be re-established and enhanced by the Project (see Section 3.2, Table 3-4) is represented as a “range” of habitat acreage which corresponds to the Project WSE range (between 6.5ft and 8.5ft, with a maximum WSE of 9.5ft City Datum). Predicted ranges of Project-generated habitat increases are sourced from the Project’s CEQA/NEPA document (see Draft EIR/EIS Section 3.4.5.1, Operational Impacts, *Estimating Vegetation Response to Changes in Lake Levels*, pages 3.4-83 through 3.4-87; ESA, 2016), which utilized a GIS-based analysis to estimate vegetation response to changes in WSE over time using vegetation data from 2011, topography, bathymetry, slope, and output from hydrologic modeling, combined with a set of “action rules” to dictate how vegetation would respond. For the purposes of the Compensatory Mitigation Plan, and for the determination of required mitigation ratios/ credits per the USACE’s Mitigation Ratio calculator, we have utilized the range of predicted habitat acreages in order to acknowledge the range of possible realistic Project-generated outcomes. These Project-generated habitat acreages (or net increases in wetlands and open waters resulting from the long-term increase in WSE) are expected to be realized within approximately 4.5 years, upon completion of lake filling to the selected operational WSE, and an additional 1 to 2 years to achieve shoreline vegetation response. Stormwater diversions into the lake will begin following installation of the outlet structure in Impound Lake, approximately one year after wetlands and waters at this location are impacted by placement of permanent infrastructure. Construction impact is planned for October 2023, and initial stormwater flow diversions into the lake increasing the WSE will begin the following year in October 2024, once the diversion structure is installed. Shoreline vegetation response (e.g., wetland type conversion, enhancement, and expansion) to the operational WSE is expected to be realized within one to two years of achieving the selected WSE, expected to occur in winter 2028/2029 (but dependent upon normal or above-average rainfall), which would result in mitigation fulfillment by winter 2030-2031.

Table 6-1 and the paragraph that follows presents information from the SFBRWQCB RWRMMP related to compensatory mitigation accounting for waters of the State and considers the type conversion of herbaceous wetlands to open water and riparian wetlands to herbaceous wetlands under Project operation. This information is provided to the Commission for context in understanding why the Project is considered to be self-mitigating by the SFBRWQCB.

TABLE 6-1
PERMANENT IMPACTS TO WATERS OF THE STATE AND REQUIRED MITIGATION, IN ACRES

Aquatic Resource:	Description of Impacts	Permanent Impacts Requiring Mitigation	Required Mitigation per USACE SOP for Mitigation[a] [Req'd Ratio]	Notes
Impacted Aquatic Resources for which Wetlands were Applied as Mitigation:				
Freshwater marsh Wetlands – Lake Merced	Outlet Structure: new structure (Impound Lake)	0.013	0.042 [3.27:1]	"In-kind" mitigation: Project-generated Lake Merced Wetland acreage utilized.
Arroyo willow Wetlands (Riparian Areas) – Lake Merced	Outlet Structure: new structure (Impound Lake); Overflow Structure (South Lake)	0.063	0.063 [1:1*]	"Out-of-kind" mitigation: Project-generated Lake Merced Wetland acreage utilized (as the highest-value habitat available).
'riparian' areas – Vista Grande Canal[b]	Canal: conversion of portion of trapezoidal lined stormwater conveyance channel to closed box culvert (with created treatment wetlands atop)	0.312	0.312 [1:1*]	"Out-of-kind" mitigation: Project-generated Lake Merced Wetland acreage utilized (as the highest-value habitat available).
Subtotal:		***0.388 ac***	***0.417 ac***	
Impacted Aquatic Resources for which Open Waters were Applied as Mitigation:				
Open Waters – Lake Merced	Outlet Structure: new structure, and wetland pump (Impound Lake); Overflow Structure: Pipeline anchors + fish screen slab (South Lake)	0.066	0.203 [3.08:1]	"In-kind" mitigation: Project-generated Lake Merced Open Waters acreage utilized. *See also Table 2 below*.
'open waters' areas – Vista Grande Canal[c]	Canal: conversion of portion of trapezoidal lined stormwater conveyance channel to closed box culvert (with created treatment wetlands atop)	0.267	0.267 [1.1*]	"In-kind" mitigation: Project-generated Lake Merced Open Waters acreage utilized.
Open Waters - Pacific Ocean	Ocean Outlet: new structure results in minor new impacts in waters at northern wing wall area, but large footprint of existing outlet structure in waters will be removed, resulting in a net benefit - see 'Project Benefits' below, re. net removal acreage (see also Fig 15-6)	-0.0085 (see Notes)	N/A	Project will result in 0.0085 ac net increase (restoration) of open waters following completion of construction, per complete restoration of 0.2470-ac temporary impact area, and per the permanent removal of a portion of the existing structure (-0.009ac) less the new permanent impact area (0.0005ac). As such, compensatory mitigation is not needed for this habitat.
Subtotal:		***0.325 ac***	***0.470 ac***	Re. 'Permanent Impacts Requiring Mitigation': 0.325 ac is the resulting number after deducting -0.0085 ac per net restoration of Open Waters – Pacific Ocean (see above), and subsequent rounding.
TOTAL:		**0.713 ac**	**0.887 ac**	Re. 'Permanent Impacts Requiring Mitigation': 0.713 ac is the resulting number after deducting -0.0085 ac per net restoration of Open Waters – Pacific Ocean (see above), and subsequent rounding.

NOTES: WSE – water surface elevation
* Calculator ratio was less than 1:1 (when expressed as X:1), but per Instructions, minimum of 1:1 must be used when performing a qualitative comparison of functions and values (per Step 2a).
[a] Mitigation Requirements (acreages and ratios) were calculated following the U.S. Army Corps of Engineers (USACE) South Pacific Division's (SPD) Standard Operating Procedure (SOP) for Determination of Mitigation Ratios (SOP for Mitigation), identified by the USACE as 12501-SPD Regulatory Program Standard Operating Procedure for Determination of Mitigation Ratios, as requested by the RWQCB.
[b] The state-jurisdictional status of the Vista Grande Canal is disputed by Daly City. The USACE determined the Vista Grande Canal to be non-jurisdictional in accordance with federal regulations pursuant to Section 404 of the CWA. For the purposes of this exercise, the Vista Grande Canal has been included in these calculations.
[c] Ibid.

Table 6-1 depicts the Project's permanent impacts to waters of the State and compensatory mitigation requirements as documented in the *Compensatory Mitigation Plan* (and its Table 1) as presented to the SFBRWQCB in the RWRMMP. Note that within Table 6-1 (as prescribed in the *Compensatory Mitigation Plan*), "Wetlands" at Lake Merced consist of freshwater marsh wetlands, and "Riparian Areas" at Lake Merced consist of arroyo willow wetlands. The Canal riparian banks are characterized in Table 6-1 as the Canal "riparian" areas. Because the compensatory mitigation ratios for permanent impacts to riparian areas at Lake Merced (arroyo willow wetlands) and the Canal "riparian" areas (banks) consider type conversion for the re-established and enhanced herbaceous (freshwater marsh) wetlands at Lake Merced expected under Project operation, future monitoring efforts (i.e., baseline or fulfillment monitoring) will not distinguish between wetland types. Rather, monitoring will document presence and extent of open water, one-parameter wetlands,[24] and uplands within the Lake Merced system according to the methods described in sections 6.1 and 6.2, below.

Table 6-2 summarizes impacts on potential ESHA-wetlands from new infrastructure and construction disturbance for which compensatory mitigation is required beyond onsite restoration of the construction disturbance area, and for which passive mitigation through Project operation is proposed (originally presented in Table 3-3). The 1.276 acres (A)[25] or 1.270 acres (B)[26] of created wetlands required as mitigation for permanent impacts to ESHA wetlands under the Project is within the predicted (net) range of expanded herbaceous wetlands at Lake Merced (between 2.04 and 3.41 acres, predicted to be primarily California bulrush marsh).

The following subsections include a description of the methods prescribed to document baseline conditions, and to document the response of shoreline vegetation and extent of increased open water and wetlands habitats following implementation of the Project. The anticipated outcome is to fulfill the Project's compensatory mitigation requirement for permanent construction impacts to both ESHA-wetlands and State-jurisdictional open waters and wetlands through operational increase of lake water levels and the passive re-establishment[27] and enhancement of shoreline wetlands and open waters within the Lake Merced system, resulting in long term net increases in the acreage and quality of these waters, as detailed in the *Compensatory Mitigation Plan*.

6.1 Establishing a Baseline

As introduced above, the Project EIR/EIS included an analysis of predicted changes to shoreline vegetation in response to restored water surface elevations at Lake Merced under Project operations. The analysis used alliance-level vegetation mapping data of the lake system and modeled responses to different operational water level scenarios (see DEIR/EIS Section 3.4.5.1,

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24 One-parameter wetlands considered waters of the State are characterized by having either hydrology, hydric soils, or hydrophytic vegetation (as identified on the current USACE National Plant List), rather than wetlands containing all three parameters which would qualify as waters of the U.S.

25 Mitigation requirement associated with PRGC staging area option A.

26 Mitigation requirement associated with PRGC staging area option B.

27 Based on historic higher WSEs and the expectation that similar habitats existed with those higher historic WSEs.

Operational Impacts, *Estimating Vegetation Response to Changes in Lake Levels*, pages 3.4-83 through 3.4-87; ESA 2016).

TABLE 6-2
PERMANENT IMPACTS TO POTENTIAL ESHA WETLANDS AND REQUIRED MITIGATION, IN ACRES

Potential ESHA Resource	Impact (ac) T/LTT/P [a]	Mitigation Ratio [b]	Compensatory Mitigation (ac)	Onsite Restoration (ac)	Additional Creation (ac)	Notes
Lake Merced Wetlands						
California bulrush marsh *Schoenoplectus californicus Herbaceous Alliance*	0.039 (Opt. A) 0.050 (Opt. B) (LTT)	1.5:1	0.058 (A) 0.074 (B)	0.095 (A) 0.106 (B)	0.015 (A) 0.020 (B)	In-kind creation: Project-generated Lake Merced Wetland acreage utilized.
	0.013 (P)	4:1	0.051			
Smartweed – cocklebur patches *Polygonum (=Persicaria) lapathifolium – Xanthium strumarium Herbaceous Alliance*	0.077 (Opt. A) 0.079 (Opt. B) (LTT)	1.5:1	0.115 (A) 0.118 (B)	0.020 (A) 0.022 (B)	0.095 (A) 0.096 (B)	"Out-of-kind" mitigation: Project-generated Lake Merced Wetland acreage utilized (as the highest-value habitat available).
Arroyo willow thickets *Salix lasiolepis Shrubland Alliance*	0.030 (Opt. A) 0.007 (Opt. B) (LTT)	1.5:1	0.045 (A) 0.011 (B)	0.274 (A) 0.250 (B)	0.920 (A) 0.907 (B)	"Out-of-kind" mitigation: Project-generated Lake Merced Wetland acreage utilized (as the highest-value habitat available).
	0.287 (P)	4:1	1.147			
Canal Wetlands						
Arroyo willow thickets *Salix lasiolepis Shrubland Alliance*	0.0616 (P)	4:1	0.246	-	0.246	"Out-of-kind" mitigation: Project-generated Lake Merced Wetland acreage utilized (as the highest-value habitat available).
Total Additional Mitigation Required					1.276 (A) 1.270 (B)	

NOTES:
[a] T = Temporary; LTT = Long-term Temporary; P = Permanent
[b] All temporary impacts require that 1) there be no significant ground disturbance, and 2) that vegetation recovers to comparable age classes and/or size structure distributions by the end of the designated period (i.e., short term or long term). Short-term temporary impacts are those where vegetation recovery occurs within 12 months of the *initial* point of disturbance. Long-term temporary impacts are those that may be intermittent or sustained for up to a 24-month period such that vegetation recovery may require more than 12 months from the *initial* point of disturbance but no more than 12 months from the *conclusion* point of disturbance, thus effectively allowing for as much as 36 months to fully recover. Assumes site restoration requirement of 1.5:1 (acres mitigated : acres impacted), based upon staff report for CDP application 2-20-0281 (Caltrans Gleason Beach Highway 1 Realignment). Available at: https://documents.coastal.ca.gov/reports/2020/11/F10a/F10a-11-2020-report.pdf. Permanent impacts include areas or key ecological functions that would be lost to development, frequently disturbed in order to maintain development, involve significant ground disturbance, or necessitate more than 12 months for recovery following the *conclusion* of disturbance. Assumes site restoration requirement of 3:1 for upland ESHA, 4:1 for wetland ESHA based on guidance received from and correspondence with Commission staff.

SOURCE: ESA, 2020. Memorandum: Vista Grande Drainage Basin Improvement Project: Delineation of Wetlands and Waters Subject to California Coastal Commission Jurisdiction. December 4, 2020.
Garske-Garcia, Lauren, Ph.D. – Senior Ecologist. Memorandum: Impact Definitions and Mitigation Framework for Gleason's Beach Highway 1 Realignment. California Coastal Commission. October 8, 2020.

As described in Section 3.2, the vegetation data used in the modeling, mapped within the Lake Merced system relies on the 2011 *Lake Merced Vegetation Mapping Update* (Nomad, 2011). This data has supported the Project Aquatic Resources Delineation and subsequent regulatory agency permit applications. Polygon adjustments were made within the Project impact areas where necessary, based on field assessments conducted by ESA botanists/restoration ecologists between 2012 and 2021.

Although the majority of this vegetation mapping data is from 2011, it is the most comprehensive dataset available for the Lake Merced system and, therefore, the best resource to use in establishing a baseline for monitoring vegetation response to increased lake levels during Project operation. Current aerial imagery will be compared with the vegetation dataset to understand whether the extent of shoreline vegetation has changed in response to water level fluctuations between 2011 and when stormwater diversions into South Lake are expected to begin (October 2024).

Prior to initiating stormwater diversions into South Lake from the Canal, a field survey at several locations around Lake Merced will be conducted to verify:

1. the limits of open water;
2. the extent of one-parameter wetlands that would be considered waters of the State; and
3. the extent of ESHA vegetation alliances.

The field surveys will utilize paired delineation sample points similar to the methods supporting the Project Aquatic Resources Delineation (see Appendix A). A minimum of ten monitoring locations will be established around the lake with samples taken to document baseline conditions ahead of the operations phase when lake water levels will be allowed to increase through stormwater influx to the selected operational WSE. Fixed, permanent transects will be established at the monitoring locations perpendicular to the shoreline. Spatial data will be taken along the transects at the boundaries of open water and one-parameter wetlands using high accuracy GPS equipment. Photo documentation will be established at each of the monitoring locations. Field data will then be compared with the 2011 vegetation dataset and adjustments will be made as needed to establish the baseline conditions from which compensatory mitigation fulfillment for permanent impacts through wetland re-establishment and enhancement at Lake Merced can be measured. The baseline dataset will consist of the 2011 vegetation dataset adjusted to reflect the extent of open water, one-parameter wetlands, and ESHA vegetation alliances documented during the baseline field assessment at the transect monitoring locations. The extent of these resources at these transect locations (depicting the delta from the 2011 vegetation dataset) will then be extrapolated throughout the entirety of the 2011 dataset using lake bathymetry and shoreline topography data. The resulting baseline dataset will contain adjusted data for these three categories which documents ESHA vegetation alliances and waters of the State throughout the entire Lake Merced system. Certain, isolated upland ESHA vegetation alliance polygons of particular interest to the Commission (e.g., Canyon live oak shrubland on the northeast side of North Lake or eucalyptus forest containing rookeries) may be added to the baseline survey where the extrapolation mapping exercise is not applicable. These specific upland ESHA vegetation alliance polygons will be mapped in the field during the baseline assessment using high accuracy

GPS equipment. Rookeries in eucalyptus forest at North Lake and South Lake will be surveyed for activity and functionality during the baseline assessment. The results of the baseline assessment will be compiled into an internal memorandum for comparison with future monitoring data.

Table 6-3 presents the potential ESHA vegetation alliances of the Lake Merced shoreline that could be affected by lake level increases under Project operation. See Section 3.2, Tables 3-4, 3-5, and 3-6, for predicted changes in vegetation acreage per alliance and per operational WSE scenario.

TABLE 6-3
POTENTIAL ESHA VEGETATION ALLIANCES AFFECTED BY PROJECT OPERATION

Manual of California Vegetation Alliance[a]

Wetlands	Uplands
California bulrush marsh + *Schoenoplectus californicus Herbaceous Alliance*	Blue gum eucalyptus groves *Eucalyptus globulus Semi-Natural Woodland Stands*
Arroyo willow thickets + *Salix lasiolepis Shrubland Alliance*	California blackberry Shrubland Alliance + *Rubus ursinus Shrubland Alliance*
Smartweed – cocklebur patches + *Polygonum lapathifolium – Xanthium strumarium Herbaceous Alliance*	Choke cherry thickets +[b] *Prunus virginiana Provisional Shrubland Alliance*
Slough sedge – Water-parsley – Small-fruited bulrush marsh + *Juncus lescurii Herbaceous Alliance*	Ice plant mats *Carpobrotus edulis Semi-Natural Herbaceous Stands*
NA - Giant vetch *Vicia gigantea*	Coyote brush – lizard tail scrub + *Baccharis pilularis - Eriophyllum staechadifolium Shrubland Alliance*
Cattail marshes *Typha (angustifolia, domingensis, latifolia) Herbaceous Alliance*	Wax myrtle scrub + *Morella californica Shrubland Alliance*
	NA – Vancouver rye grassland + *Elymus × vancouverensis*
	Canyon live oak shrubland + *Quercus chrysolepis Shrubland Alliance (in part)*

NOTES: + indicates CDFW sensitive alliance.
[a] Sawyer, J.O., T. Keeler-Wolf, and J.M. Evens. 2009. A Manual of California Vegetation, Second Edition. California Native Plant Society, Sacramento, CA. 1300 pp.
[b] Choke cherry thickets has provisional status as a CDFW sensitive alliance; CCC may identify it as ESHA for this reason. Not identified in the EIR/EIS as a Sensitive Natural Community.

6.2 Compensatory Mitigation Fulfillment Monitoring Methods and Reporting

It is expected that Lake Merced shoreline vegetation changes, in response to the increased WSE, will be measurable within one to two years after achieving the final operational WSE (estimated for winter 2028/2029). This timeline considers the species characteristics and lifecycle of the existing freshwater marsh (California bulrush marsh and Smartweed – cocklebur patches) and arroyo willow riparian wetlands (arroyo willow thickets), as well as other wetland vegetation alliances within the lake system that would be affected by the higher operational WSE. A direct response to the increased WSE should be observed within two growing seasons for all vegetation alliances within the lake system – both herbaceous and shrub-dominated alliances (estimated for 2030). Generally, the herbaceous wetland response to the increased WSE is expected to be more rapid than the shrub-dominated wetland response, but response in both communities is anticipated to be measurable within two years nonetheless.

6.2.1 Monitoring Schedule

Compensatory mitigation fulfillment monitoring will be carried out in May, beginning two years after the operational WSE has been achieved, estimated in 2030/2031, and will continue on an annual basis until mitigation acreage requirements are achieved.

6.2.2 Monitoring Methods

Monitors will visit the monitoring transects established during the baseline assessment and specific upland ESHA vegetation alliance polygons identified by the Commission to document:

1. the extent of open waters;
2. the boundaries of one-parameter wetlands; and
3. the boundaries of ESHA vegetation alliances.

Consistent with baseline survey approach, high accuracy spatial data will be collected at points along the same monitoring transects as baseline data collection, corresponding with the boundaries of open water, one-parameter wetlands, and ESHA vegetation alliances. Upland vegetation alliances of interest will be mapped as a polygon in the field for comparison with baseline conditions. Eucalyptus forest containing rookeries at North and South Lake will be surveyed for changes in activity and functionality related to operational WSEs. Photo documentation of the points and vegetation along the transects will be taken. Qualitative notes on the health and vigor of these habitats will also be documented. For example, the final response from the shrub-dominated wetlands (e.g., arroyo willow riparian wetlands) may not be realized by this site visit but indications of movement from this habitat upslope, or die-off resulting from sustained inundation, should be apparent. Spatial monitoring data will be compared with baseline data to quantify the extent of shoreline vegetation change and determine whether compensatory mitigation requirements have been achieved.

Should the monitoring results indicate that open waters and shoreline wetlands have not increased to the extent necessary to achieve compensatory mitigation requirements of 1.276 acres (A)[28] or 1.270 acres (B)[29] one-parameter wetlands, but some progress toward this goal is measurable, monitoring will continue on an annual basis until this acreage is achieved or until the shoreline vegetation response is more certain. This approach may be combined with adaptive management measures such as additional proactive enhancement of existing wetlands around Lake Merced through invasive vegetation removal, supplemental planting, or temporary irrigation if needed, in

28 Mitigation requirement associated with PRGC staging area option A.
29 Mitigation requirement associated with PRGC staging area option B.

coordination with San Francisco Recreation and Parks Department. This adaptive management approach will maintain compensatory mitigation within the same watershed where impacts occurred and supplement the Project's existing passive wetland enhancement approach to compensatory mitigation. For impacts to upland ESHA vegetation alliances quantified using data collected during the fulfillment monitoring event and compared with baseline conditions, the Project will implement necessary compensatory mitigation onsite, upland of these existing communities around the lake, or off site as out of kind habitat type improvements within the watershed. Mitigation planting will be coordinated with and approved by the San Francisco Recreation and Parks Department as land managers or coordinated with the Commission for acceptable off site mitigation fulfillment.

6.2.3 Reporting

An annual monitoring report will be submitted to the Commission by January 31st of the year following compensatory mitigation fulfillment monitoring, for each year the monitoring is conducted, until compensatory mitigation requirements are achieved.

Annual reports will include, at the minimum, the following information:

- Summary description of the monitoring methods, including data collection and analysis;
- Summary of baseline conditions;
- An overview of the lake filling period, a general discussion of conditions (changes) observed along monitoring transects, and quantitative comparisons of open water and one-parameter wetlands along monitoring transects;
- Analysis of success in relation to compensatory mitigation requirements;
- Color photographs of the monitoring transects taken from the photopoint locations;
- A map of the Lake Merced system with updated boundaries of open water, wetlands, and ESHA vegetation alliances representative of the monitoring data, depicting both baseline and current monitoring year boundaries, and photopoint locations, and;
- A conclusion explaining how compensatory mitigation requirements have been achieved; or if continued monitoring is warranted, to capture the full response of shoreline vegetation to increased WSE.

6.3 Contingency Plan

If monitoring indicates the vegetation response to operational lake levels is insufficient to compensate for construction impacts by monitoring year five, then Daly City will submit a plan for modifying the lake levels accordingly, or implementing additional on- or off-site compensatory mitigation to otherwise fulfill mitigation requirements of the Project. This approach would also apply to any necessary upland ESHA vegetation alliance mitigation that is not able to be implemented onsite around the Lake Merced shoreline.

SECTION 7
Plan Preparation and References

7.1 Plan Preparation

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7.2 References

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memorandum

date December 4, 2020

to Director Tom Piccolotti, Daly City Department of Water Resources

from Rachel Haines

subject Vista Grande Drainage Basin Improvement Project: Delineation of Wetlands and Waters Subject to California Coastal Commission Jurisdiction

Introduction

This memorandum documents the extent of wetlands and waters within the Vista Grande Drainage Basin Improvement Project (Project) area under regulatory authority of the California Coastal Commission (CCC or Commission) including, and in addition to, federal wetlands and waters jurisdictional to the U.S. Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act (CWA) and Section 10 of the Rivers and Harbors Act (RHA), as described in the attached Aquatic Resources Delineation prepared for the Project (**Attachment 1**).[1] This memorandum also describes Project construction and operational impacts to Commission wetlands and waters as well as measures to avoid, minimize, and mitigate Project impacts to these resources.

Project Location

The Project is located on the western portion of the San Francisco Peninsula at the southern edge of San Francisco and northern edge of Daly City with components located in both the City of Daly City, San Mateo County, and the City and County of San Francisco (**Figure 1**).

Project Description

Daly City is proposing the Project to address storm-related flooding that currently occurs in the Vista Grande Drainage Basin (Basin) and to provide other environmental benefits, including management of water levels within Lake Merced. Lake Merced is made up of four individual but connected lakes (East, North, South, and Impound Lakes) and is managed by the City and County of San Francisco through the San Francisco Public Utilities Commission (SFPUC). The SFPUC maintains the lake as a non-potable emergency water supply (e.g., for firefighting, sanitation purposes) for San Francisco and is a responsible agency for the Project. Historically, the Basin was part of the Lake Merced Watershed. The Vista Grande Canal and Tunnel were built in the 1890s to divert stormwater away from the lake to an outlet at the Pacific Ocean, below what is now Fort Funston. The

1 ESA, 2020. Vista Grande Drainage Basin Improvement Project Aquatic Resources Delineation, prepared for the City of Daly City, September 2014, revised June 2020.

existing canal and tunnel do not have adequate hydraulic capacity to convey peak storm flows, periodically causing flooding in adjacent low-lying residential areas and along John Muir Drive during storm events. A portion of the Vista Grande Tunnel, once enclosed within the cliffs at Fort Funston, has become exposed due to the ongoing erosion of the cliff face. The Project would alleviate flooding and improve the ocean outlet, while reconnecting a portion of the lake's historic watershed. Operational components of the Project provide for management of water elevations in Lake Merced and a Lake Management Plan that would implement water quality best management practices.

The Project would consist of the following structural components as depicted in **Figures 2** and **3**:

- Partial replacement of the existing Vista Grande Canal to incorporate a gross solid screening device, a constructed treatment wetland, and diversion and discharge structures to route some stormwater (and authorized non-stormwater) flows from the Vista Grande Canal to Lake Merced;
- Modification of the existing effluent sewer pipeline so that it may be used year round to convey treated effluent by gravity from the Daly City Wastewater Treatment Plant to the existing outlet and diffuser;
- Replacement of the existing Vista Grande Tunnel to expand its hydraulic capacity and extend its operating lifetime and replacement of the Lake Merced Portal to the tunnel; and
- Replacement of the existing ocean outlet structure and a portion of the existing submarine outfall pipeline at Fort Funston.

Setting

The Project includes three main sites: Lake Merced (which includes the Vista Grande Canal), Fort Funston (which includes Ocean Beach), and the Avalon Canyon access road.

The Lake Merced site includes a western segment of Impound and South Lake, John Muir Drive, and the Vista Grande Canal from the intersection of Lake Merced Boulevard and John Muir Drive north to the northern edge of the Olympic Golf Club. This site is surrounded to the north and east by Lake Merced and to the south and west by Olympic Golf Club. This site is surrounded to the north and east by Lake Merced and to the south and west by Olympic Golf Club. Lake Merced is the largest natural freshwater lake in San Francisco. Lake Merced was historically a lagoon fed by five relatively small streams and groundwater, with occasional connection to the Pacific Ocean.[2] Beginning in the 1870s the lake was used as a municipal water supply for San Francisco and by the late 1880s the lake was completely separated from its natural point of discharge at the Pacific Ocean due in large part to water diversions for municipal use and urban development. In 1895, earthen dams were constructed to divide the lagoon into separate lakes and permanently sever Lake Merced's connection to the ocean.

The Fort Funston site consists of Fort Funston Road, an existing paved road and the proposed Project staging area of approximately 4 acres, located in disturbed dune vegetation, north and east of the main parking lot. The Fort Funston site also includes the existing Daly City and SFPUC ocean outlet structures, submarine outfall pipe, beach, and a small staging area on the bluffs above the outlet structures. The Pacific Ocean lies to the west of this site, Lake Merced and Olympic Golf Club to the east, and undeveloped coastline parks to the north and south. Fort Funston is a former defense installation located in southwestern San Francisco and is presently owned and managed by the National Park Service as part of the Golden Gate National Recreation Area.

2 San Francisco Planning Department, 2011. *Significant Natural Resource Areas Management Plan Draft Environmental Impact Report*, Planning Department Case No. 2005.1912E, State Clearinghouse No. 2009042102, August.

SOURCE: McMillen Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 1
Location and Jurisdiction

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SOURCE: Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 2

Proposed Project Components (Canal)

2-23-0862
Exhibit 5
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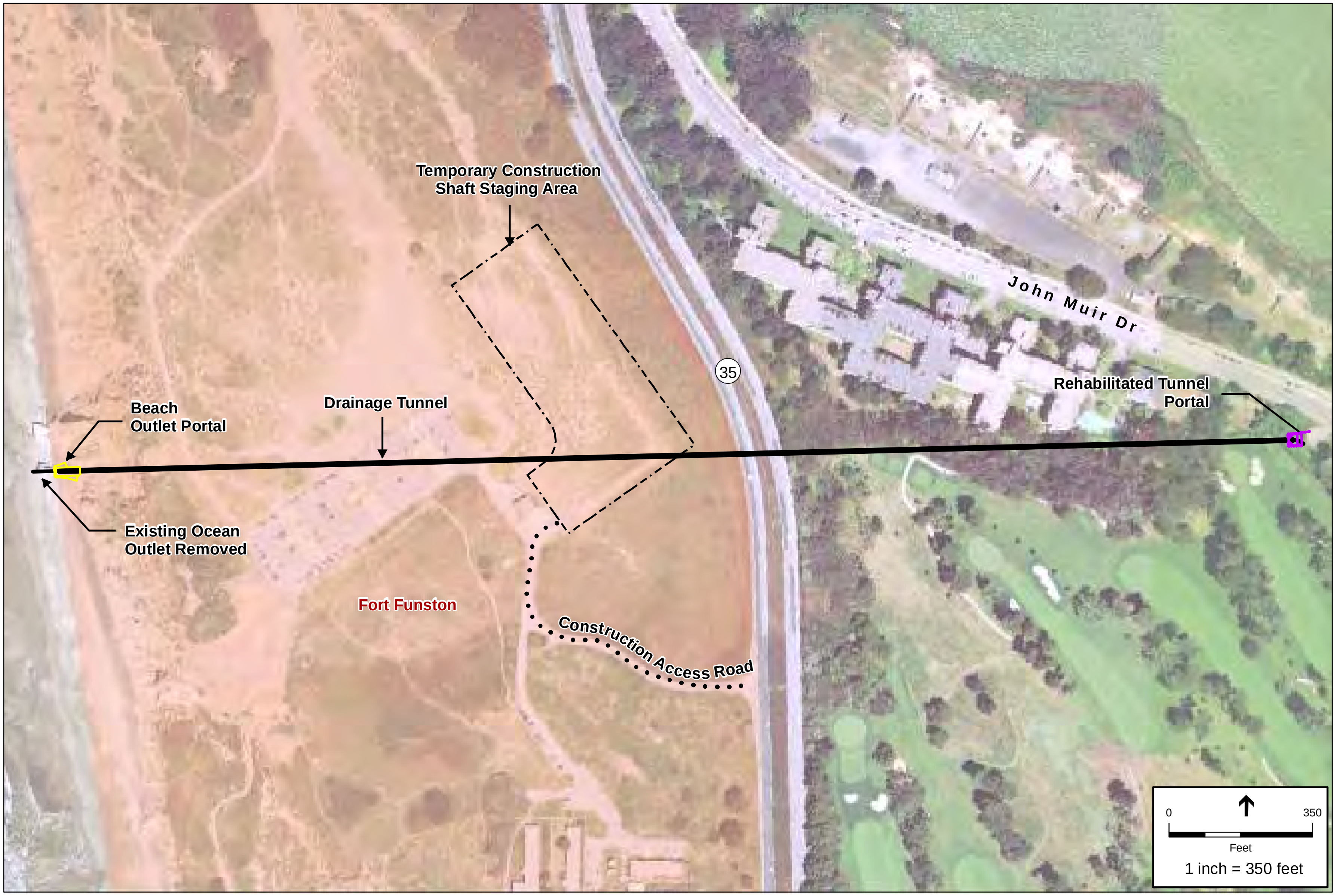

SOURCE: Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 3

Proposed Project Components (Tunnel)

The Avalon Canyon site consists of a paved access road and adjacent (restored) coastal scrub habitat, a transitional area between upland and beach zones of coastal dune scrub, and the beach from end of the access road north to the Ocean Outlet. Large and severe landslides have occurred adjacent to and within this site and complete revegetation of disturbed portions of the canyon followed extensive grading and realignment of the roadway in 2000 and 2005, leaving little undisturbed, naturally-occurring vegetation.[3] Residential development surrounds the site on the north, east, and south. An approximately 275-foot rock revetment (riprap) exists along the shore in this location, between the western terminus of Avalon Canyon Road and the beach. To the west of the site is the Pacific Ocean.

Methods

This section summarizes the aquatic resources delineation methods used to identify aquatic resources subject to USACE jurisdiction under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act and describes the methods used to identify additional wetlands and waters that may be subject to CCC jurisdiction.

Delineation Study Area

The study area for identifying aquatic resources jurisdictional to the Commission consists of the Project disturbance footprint depicted on **Figure 4**. This is a refined study area from the broader assessment of federal wetlands and waters in the Project vicinity described in **Attachment 1**.[4]

Federal Aquatic Resources Delineation

ESA conducted a formal delineation of all aquatic resources potentially subject to USACE jurisdiction within the delineation study area on November 7, and December 3, 2012, confirmed conditions remained accurate during a site visit on October 4, 2018, and surveyed some of the Project impact areas on July 8, 2020.[5] The federal aquatic resources delineation process involved determining the boundaries between wetlands, waters, and surrounding uplands through the investigation of the three parameters that define a federal wetland: vegetation, soils, and hydrology. The delineation identified Lake Merced and its adjacent wetlands and the Pacific Ocean below the high tide line at Fort Funston as aquatic resources within the study area subject to jurisdiction under both Section 404 of the CWA and Section 10 of the RHA. On April 29, 2016, the USACE confirmed that the Vista Grande Canal is not considered a water of the U.S. in an approved jurisdictional determination (AJD). Within the overall federal aquatic resources delineation study area, a total of 18.830 acres (820,254 square feet) of aquatic features are potentially jurisdictional waters of the U.S. subject to the CWA; a subset of those waters, totaling 12.372 acres (538,924 square feet), are potentially also subject to Section 10 of the RHA. The results of this Aquatic Resources Delineation is incorporated by reference as Attachment 1.

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[3] Terra Engineers, 2015. Avalon Canyon Access Road and Storm Drain project profile, Daly City, CA. [http://www.terraengineers.com/avaloncanyon/] Accessed July 28, 2015.

[4] ESA, 2020. Vista Grande Drainage Basin Improvement Project Aquatic Resources Delineation, prepared for the City of Daly City, September 2014, revised June 2020.

[5] ESA, 2020. Vista Grande Drainage Basin Improvement Project Aquatic Resources Delineation, prepared for the City of Daly City, September 2014, revised June 2020.

The delineation study area did not include the beach south of the Ocean Outlet area (which would be used for equipment access from Avalon Canyon), the beach at the Avalon Canyon access area, nor the reach of the Lake Merced shoreline adjacent to the Project's Pacific Rod and Gun Club (PRGC) Staging Area site.[6] However, limits of federal jurisdiction at the two beach locations were established based upon tidal datum and using the same methodology as used for the Ocean Outlet area. Limits of federal jurisdiction at the reach of the Lake Merced shoreline adjacent to the project's PRGC Staging Area were established based upon a delineation performed by Coast Ridge Ecology for an adjacent project.[7] These jurisdictional limits, in combination with ESA's federal Aquatic Resources Delineation report results (Attachment 1) are included in the limits of wetland and non-wetland (open water) coastal waters regulated by the Commission, described below.

California Coastal Commission Aquatic Resources Delineation

Pursuant to Pub. Res. Code § 30233, the Coastal Commission has the authority to regulate dredging, diking and filing of certain waters found within the coastal zone, including open coastal waters, coastal wetlands, estuaries, and lakes (referred to generally in this memorandum as "coastal waters"). This section presents the methods used to identify coastal waters in the Project area. As discussed, the approach builds upon the results of the federal Aquatic Resources Delineation report to determine the extent of such coastal waters. This memo further distinguishes between coastal wetland waters and non-wetland waters. Finally, this section identifies other aquatic features within the coastal zone considered, but determined not to be coastal waters, and the rationale for that determination.

Coastal Commission Wetlands Definition

The Project lies within the Coastal Zone and is subject to regulation under the Coastal Act and the certified local coastal programs (LCP) of the local jurisdictions within which the project is proposed. While components of the Project are proposed within Daly City, San Francisco, and San Mateo County, each of which has a certified local coastal program, all parties have agreed to the CCC's consolidated coastal permit review. Therefore, with respect to wetlands, this memorandum follows the CCC wetland definition as described below, but also draws upon the appropriate LCPs as guidance.

6 The beach south of the Ocean Outlet area was not included, as only upland will be utilized for construction equipment access; the Avalon Canyon access area was not included as only upland areas (above the MHTL) will be utilized for construction equipment access and sand placement atop the existing rip rap above the MHTL; and the reach of Lake Merced shoreline adjacent to the Pacific Rod and Gun Club (PRGC) Staging Area site was not included because this staging area option was not added to the Project until early 2020 (postdating the 2012 delineation and 2018 confirmation site visit). Upon the addition of this staging area in 2020, ESA obtained permission to utilize delineation information developed by CRE for adjacent the Lake Merced West Project to calculate potential impacts at this location (Section 6.0).

7 Coast Ridge Ecology (CRE) 2020. Lake Merced West Recreation Project Aquatic Resources Delineation. Prepared for the San Francisco Public Utilities Commission, April 2020.

SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

Figure 4
California Coastal Commission - Aquatic Resources Delineation Study Area
Project Disturbance Areas - 100% Design

ESA

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Wetlands in California's Coastal Zone are regulated under the California Coastal Act (CCA) of 1976. The Commission broadly defines wetlands under the Coastal Act (Cal. Pub. Res. Code §30121) as follows:

> Wetland means lands within the coastal zone which may be covered periodically or permanently with shallow water and include saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, or fens.

The Commission regulations (California Code of Regulations Title 14 (14 CCR)) provide further information regarding those aquatic features that are regulated as wetlands for purposes of the California Coastal Act:

> "Wetland shall be defined as land where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes, and shall also include those types of wetlands where vegetation is lacking and soil is poorly developed or absent as a result of frequent and drastic fluctuations of surface water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats." (14 CCR Section 13577).

The CCC regulations do not provide definitions of hydric soils or hydrophytic vegetation, but rely on the *1987 Army Corps of Engineers Wetland Delineation Manual*, *USFWS List of Plant Species that Occur in Wetlands* (which has been updated to include the *National Wetland Plant List*, and the *Field Indicators of Hydric Soils in the United States* as appropriate documents to use when determining the presence of wetlands).[8,9,10] The CCC also acknowledges that the observation of indicators in the field is subject to uncertainty and error and wetland delineators must exercise professional judgment when conducting a wetland delineation.

San Francisco's LCP, the Western Shoreline Area Plan, does not include a definition of wetlands additional to the Coastal Act or Commission regulations. The Daly City LCP, Coastal Element (1984), similarly does not define wetlands. The San Mateo County LCP includes a more detailed definition of wetlands similar to the definition, listed above, and provides a list of plant species typically found within wetlands of the County and indicates that the aquatic feature must have cover of some combination of these plants exceeding 50% to qualify as a wetland, unless it is a non-vegetated mudflat.[11] The San Mateo County LCP's definition would be used as guidance in the CCC's review of potential wetlands in the vicinity of the head works of the Canal, which is located in unincorporated San Mateo County (see Figure 2 in the CDP Application). The San Mateo County LCP guidance regarding wetland delineation based on the presence of specific hydrophytes would not apply to classification of the wetlands in and around Lake Merced, given their location within the San Francisco LCP, Western Shoreline Area Plan. Per CCC

8 Environmental Laboratory, Department of the Army. 1987. Corps of Engineers Wetland Delineation Manual (Technical Report Y-87-1). U.S. Army Corps of Engineers. Waterways Experimental Station. Vicksburg, Mississippi.

9 U.S. Army Corps of Engineers (USACE), 2018. National Wetland Plant List, version 3.4 http://wetland-plants.usace.army.mil/

10 Natural Resources Conservation Service (NRCS). 2018. Field Indicators of Hydric Soils in the United States, Version 8.2, 2018. Edited by L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz. U.S. Department of Agriculture, Natural Resources Conservation Service, in cooperation with the National Technical Committee for Hydric Soils.

11 Plant species listed in the San Mateo County LCP indicative of wetlands include: cordgrass, pickleweed, jaumea, frankenia, marsh mint, tule, bullrush, narrow-leaf cattail, broadleaf cattail, pacific silverweed, salt rush, and bog rush.

precedent, man-made features that might exhibit some wetlands properties (i.e., vegetation), but lack wetland hydrology, are not considered wetlands.[12]

Office Preparation

In advance of field surveys to identify wetlands meeting the Commission criteria, ESA performed a desktop review of existing vegetation mapping data within the Project disturbance area to identify areas that may be dominated by hydrophytic vegetation.

Existing vegetation mapping was informed by many survey efforts going back to 1994, performed by consultants for San Francisco and by the National Park Service staff, rather than surveys performed exclusively for the purpose of this Project. These data sets were reviewed for accuracy and confirmed through a series of field surveys by ESA biologists prior to their use in support of the 2015 Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) analysis of Project impacts to biological resources.

- **Lake Merced:** Vegetation mapped within the Lake Merced system relies on the *Lake Merced Vegetation Mapping Update*, an effort which refreshed previous vegetation maps of the Lake Merced system initiated in 2000.[13] The initial vegetation maps and classification system used the Manual of California Vegetation (MCV), first edition (1995), and classified vegetation into 44 discrete vegetation types, or series.[14] The 2011 Lake Merced Vegetation Mapping Update used the MCV second edition (2009) and classified vegetation to the alliance level, defined as "a category of vegetation classification which describes repeating patterns of plants across a landscape," or a more detailed vegetation type based on the initial 44 series mapped. [15] For consistency, the naming conventions used in the initial Lake Merced vegetation mapping effort was retained in the mapping update. The vegetation was mapped in a GIS platform using digital color aerial photography and field notes to delineate the boundaries around individual stands of vegetation through a 'heads up' digitizing process, followed by ground truthing nearly half of the vegetation polygons. ESA obtained this spatial data from San Francisco to support the Project impact analysis.
- **Fort Funston:** The National Park Service provided ESA with unpublished GIS data of vegetation communities and rare plant occurrences mapped within Fort Funston by NPS staff between 1994 and 2013. Vegetation data included polygons mapped to the association level, meaning, those plants that occur commonly in all or some parts of the alliance; however, the community classification was used in the Project's EIR/EIS analysis to describe vegetation present for consistency with other vegetation classification data available for the Project area.

Communities dominated by hydrophytic plants were noted for confirmation in the field and to identify whether these communities may be considered coastal wetlands by the Commission.

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12 California Coastal Commission, August 25, 2016, Memorandum from John D. Dixon, PhD and Jonna D. Engel, Ph.D., Ecologists to Amber Dobson, Coastal Program Analyst, Subject: Site-specific analysis of wetlands and ESHA on Banning Ranch. April 29, 2016; Revised August 25, 2016

13 Nomad Ecology, 2011. Lake Merced Vegetation Mapping Update, Lake Merced Natural Area, City and County of San Francisco, California, revised draft. Prepared for San Francisco Public Utilities Commission, May.

14 Sawyer and Keeler-Wolf, 1995. A Manual of California Vegetation. California Native Plant Society. Sacramento, USA.

15 A classification of vegetation at any level in the National Vegetation Classification Hierarchy (e.g. alliance, association) or used when vegetation has not been classified formally to a specific level. A vegetation type is typically defined on the basis of shared floristic and/or physiognomic characteristics.

Existing vegetation mapping data was not available in the vicinity of the Vista Grande Canal. Vegetation mapping in this area was conducted during the 2018 and 2020 field surveys described below.

Field Survey

As described above, ESA conducted a federal Aquatic Resources Delineation within the delineation study area on November 7 and December 3, 2012.[16] On October 4, 2018, ESA performed a field verification of the Project aquatic resources delineated in 2012 to both confirm the extent and composition of federal wetlands and waters, and also to map vegetation communities along the Vista Grande Canal. On July 8, 2020, ESA performed a field survey of the Project disturbance area along the Vista Grande Canal and the South Lake and Impound Lake shorelines where hydrophytic vegetation had been previously mapped, focusing on delineating CCC jurisdictional coastal wetlands.

During the 2018 field verification, ESA biologists investigated all wetland and drainage signatures on aerial maps of the Project disturbance area and mapped communities of hydrophytic vegetation. The biologists walked the survey area in such a manner as to ensure that visual coverage was 100 percent. All aquatic resources delineated previously were confirmed by comparing 2014 report mapping data and aerial images to existing site conditions and collecting additional data. Concurrently with the 2018 federal wetlands field verification, ESA identified and mapped the extent of hydrophytic vegetation communities within the Project disturbance areas along the Vista Grande Canal.

On July 8, 2020, ESA biologists conducted a field survey within the Project disturbance area to identify any coastal wetlands and waters that may be subject to Commission jurisdiction outside of the delineated federal wetlands and waters. Surveys were conducted within mapped hydrophytic vegetation communities and other areas within the Lake Merced and Vista Grande Canal Project disturbance areas. ESA biologists collected data from soil test pits to investigate whether or not hydrophytic vegetation, hydric soils, and wetland hydrology indicators were present, and then to identify whether or not any coastal wetlands subject to Commission jurisdiction were present.

Surveyors followed the USACE's *Arid West Supplement*, as described in Project's federal Aquatic Resources Delineation, and the *Field Indicators of Hydric Soils in the United States* to identify the presence of hydric soils and followed the USACE's *Arid West Supplement* (2010), as described in federal Aquatic Resources Delineation, to determine the presence of wetland hydrology.[17, 18, 19, 20]

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16 The original Project preliminary delineation of waters of the U.S. report was submitted to the USACE in January 2014 and subsequently revised and resubmitted to the USACE in September 2014.

17 U.S. Army Corps of Engineers (USACE), 2008. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.0) ed. J.S. Wakeley, R.W. Lichvar, and C.V. Noble. ERDC/EL TR-06-16. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

18 ESA, 2020. Aquatic Resources Delineation for the Vista Grande Drainage Basin Improvement Project. Prepared for the City of Daly City, July 2020.

19 Natural Resources Conservation Service (NRCS). 2018. Field Indicators of Hydric Soils in the United States, Version 8.2, 2018. Edited by L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz. U.S. Department of Agriculture, Natural Resources Conservation Service, in cooperation with the National Technical Committee for Hydric Soils.

20 ESA, 2020. Aquatic Resources Delineation for the Vista Grande Drainage Basin Improvement Project. Prepared for the City of Daly City, July 2020.

Mapping and Acreage Calculations

As described in the federal Aquatic Resources Delineation report, Lake Merced ordinary high water mark (OHWM), federal wetland boundaries, and wetland and upland sample points were recorded in the field using a Trimble GeoXT sub-meter accuracy global positioning unit (GPS). Field notes were taken on the characteristics of each feature (vegetation type and quality, disturbance levels, etc.). Maps of vegetation around Lake Merced, digitized from aerials and field verified by ESA in 2012, 2018, and 2020, were used as a basis for the delineation.[21,22]

Mapping was done using ArcGIS 10.1. Field data was overlaid on digital ortho-rectified aerial photographs covering the study areas and the 2012 vegetation layer and used to map the delineation results. This included correction of original data based on field observations as well as heads up digitizing using field maps and notes.

Results

Coastal Wetlands and Waters in the Project Disturbance Area

The following includes a summary of results from the Project's federal Aquatic Resources Delineation report and identifies additional aquatic resources under regulatory authority of the Commission, as shown in **Table 1**. The federal Aquatic Resources Delineation documents wetlands and waters jurisdictional to the USACE in a delineation study area larger than was used for the Commission wetlands survey. This is because the Project disturbance area was still preliminary at the time of the initial federal wetlands delineation (2012) and at the time of the 2018 field verification. Since that time, the Project design has progressed and the Project disturbance limits have been fully defined. Therefore, the supplemental field survey performed in 2020 for Commission-regulated coastal wetlands and waters are specific to the temporary and permanent impact areas per the Project's 100 percent design documents (i.e., the CCC delineation study area). Table 1 depicts the acreages of potentially jurisdictional coastal wetlands and waters within the CCC delineation study area.

TABLE 1
OVERVIEW OF POTENTIALLY JURISDICTIONAL COASTAL WETLANDS AND WATERS IN THE CALIFORNIA COASTAL COMMISSION DELINEATION STUDY AREA

Wetland/Water Type	CCC Wetland/Water (acres)
Lake Merced Open Water	0.076
Freshwater Emergent Wetland	0.141
Arroyo Willow Wetland	0.345
Pacific Ocean	0.200
Total	**0.762**

21 Nomad Ecology, 2010. GIS shapefiles prepared for Lake Merced Vegetation Mapping Update, Lake Merced Natural Area, City and County of San Francisco, California. Prepared for San Francisco Public Utilities Commission.
22 ESA, 2012. GIS vegetation shapefiles prepared for the San Francisco Groundwater Supply Project Draft Environmental Impact Report. Prepared for the City and County of San Francisco.

Lake Merced

Located within the coastal zone, Lake Merced is the largest natural freshwater lake in San Francisco and currently comprises four lakes: North, East, South, and Impound Lakes. The lake shoreline is comprised of emergent wetlands bordered upslope by dense riparian scrub and narrow bands of upland vegetation or developed, landscaped areas. The emergent wetlands, riparian scrub, and open waters of Lake Merced were determined to be potentially jurisdictional coastal wetlands and waters as described below.

Freshwater Emergent Wetlands

Emergent wetlands within the CCC delineation study area are dominated by the obligate hydrophytes bulrush (*Schoenoplectus californicus*) and swamp knotweed (*Persicaria amphibia*). Associated species include water parsley (*Oenanthe sarmentosa*; OBL), Baltic rush (*Juncus balticus*; FACW), willow herb (*Epilobium ciliatum*; FACW), dotted smartweed (*Persicaria punctata*; OBL), and American speedwell (*Veronica americana*; OBL).

The Commission regulations provide a broad definition of what constitutes wetlands under Commission jurisdiction:

> “Wetland shall be defined as land where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes, and shall also include those types of wetlands where vegetation is lacking and soil is poorly developed or absent as a result of frequent and drastic fluctuations of surface water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats.” (14 CCR Section 13577).

As explained above, the CWA three-parameter regulatory definition of wetlands, and USACE delineation procedures for identifying wetlands result in classification of a narrower set of aquatic features as wetlands subject to the CWA. Given that the soils and plant criteria set forth in the Commission definition results in jurisdiction over a potentially broader set of aquatic features, wetlands considered jurisdictional by the USACE would likely also be subject to Commission jurisdiction, given the presence of hydric soils and the dominance of hydrophytic plant cover. Because Lake Merced is within the coastal zone of San Francisco, the additional wetland criteria (i.e., descriptions of hydrophytes) set forth in the San Mateo County LCP would not apply to delineation of the wetlands surrounding Lake Merced. A complete description of emergent wetlands within the study area is provided in the Attachment 1, and a summary is provided below.

Sample points SP1, SP3, SP6, SP9, and SP10 represent emergent wetland conditions (see datasheets in the federal Aquatic Resources Delineation in Attachment 1). These sample points are outside of the CCC delineation study area, but were taken within similar habitat within the federal delineation study area and are representative of emergent wetlands within the CCC delineation study area. These sample points contained wetland vegetation dominated by OBL and FACW vegetation, hydric soils, and wetland hydrology demonstrated by the presence of surface water, surface saturation, or a high water table.

Arroyo Willow Wetlands

Arroyo willow wetlands in the CCC study area are mostly dominated by arroyo willow (*Salix lasiolepis*, FACW) in the shrub layer, although there are some patches of California blackberry (*Rubus ursinus*, FAC). Associated species in the willow wetland understory include California bulrush (OBL) and swamp knotweed (*Persicaria amphibia*, OBL). Arroyo willow wetlands along Lake Merced within the CCC study area are potentially jurisdictional coastal wetlands based on Commission regulations. Portions of the arroyo willow wetlands closer to the Lake met all three wetland parameters (hydrophytic vegetation, hydric soils, and wetland hydrology) required to be considered a federal wetland and coastal wetland jurisdictional to the Commission. Arroyo willow wetlands along the upper banks of the Lake did not meet all three parameters to be considered federal wetlands; however, given the typical, annual fluctuation in water surface elevation (WSE),[23] and that field delineations occurred during the dry season, wetland hydrology necessary to support the growth of arroyo willows is likely present. Consequently, these features likely meet the definition of CCC wetlands.

Arroyo willow wetlands that met all three wetland parameters set forth in the federal wetland definition are represented by sample points SP10 and SP12. Sample point SP10 is outside of the CCC delineation study area, but was taken from similar habitat within the federal delineation study area and is representative of arroyo willow wetlands within the CCC delineation study area. Sample point SP12 is within the CCC study area. These federal three-parameter wetlands are dominated by arroyo willow (FACW), contain hydric soils, and show primary signs of wetland hydrology demonstrated by either a high water table and saturation or by the presence of sediment deposits and water stained leaves.

Because the field delineation of coastal wetlands occurred during the dry season, application of typical wet season conditions, including seasonally higher Lake WSE, were necessary to determine the full extent of Commission jurisdiction. Arroyo willow wetlands within the Lake Merced riparian corridor, above the federal wetland boundary, were therefore determined to be coastal wetlands under regulatory authority of the Commission. These coastal wetlands are represented by sample points SP13 and SP19. They are dominated by arroyo willow (FACW), but did not contain any hydric soil or wetland hydrology indicators at the time of the field visit. However, these arroyo willow-dominated areas directly abut the federal arroyo willow-dominated wetlands which are contiguous to open water areas of Lake Merced. These areas are also presumed to experience saturation or inundation at some time during each year given seasonal fluctuations in Lake Merced WSE. Furthermore, arroyo willow are deep rooted plant species and their presence along the lake shoreline, although in some areas above the limits of inundation and/or saturated soils in the dry season, indicate they are likely supported by lake hydrology rather than any other source. Thus, these areas likely meet the Commission's wetland definition.

[23] In 2018, South Lake WSE ranged 4.85 feet to 6.20 feet San Francisco City Datum (San Francisco Public Utilities Commission, 2019. *2018 Annual Groundwater Monitoring Report*, Westside Basin, San Francisco and San Mateo Counties, CA, April). Within the Lake Merced system, sources of inflow are primarily attributed to precipitation (55%) and stormwater (25%) with outflows attributed primarily to evaporation (67%), transpiration (14%) and groundwater infiltration (14%) (San Francisco Planning Department, 2011. *Significant Natural Resource Areas Management Plan Draft Environmental Impact Report*, Planning Department Case No. 2005.1912E, State Clearinghouse No. 2009042102, August.).

Pacific Ocean

The beach below Fort Funston, subject to the ebb and flow of the tide, is characterized by unconsolidated sands and no vegetation. Commission-regulated coastal waters on the beach below Fort Funston extend to the mean high tide line (MHTL), mapped at 5.29 feet (NAVD88).

Areas Considered but Determined to be Non-Jurisdictional

Vista Grande Canal

Vista Grande Canal is a trapezoidal, man-made channel within the study area originally constructed over a century ago to capture and redirect stormwater and agricultural waters from Lake Merced. The channel bed and banks consist of bricks and cement. At the time of the field delineations in 2012 and 2018, the Canal consisted of open water with occasional unvegetated sediment deposits of silt and sand-sized grains. Mosses and trapped sediment provide a substrate on the banks for annual grasses and other opportunistic herbaceous species. The upper banks above the lined channel support annual grasses, non-native trees, horticultural shrubs, and native California blackberry thickets. Few species occurring along the banks of the Canal are native riparian species and none are actually supported by water conveyed in the Canal. Although a few wetland plant species, such as cattail (*Typha latifolia*), bulrush, willow herb, and rabbitsfoot grass (*Polypogon monspeliensis*) can colonize the sediment deposits in the Canal, field observations that occurred after rain events indicate the sediment and wetland vegetation are likely to be scoured out each year by high flows in the Canal. Such vegetated areas are not permanent enough to be considered wetlands.

On April 29, 2016, the USACE issued an Approved Jurisdictional Determination (AJD; File Number 2014-00030S) in which the agency confirmed that it does not consider the Vista Grande Canal within the Project site to meet the definition of a water of the U.S. A review of historical imagery indicated the Vista Grande Canal, a non-tidal feature, was excavated in dry uplands and did not follow any natural drainage feature or intersect a natural tributary. Further, the age of the channel, the brick and concrete lined invert, and low physical and biological functions all contributed to the USACE’s decision not to assert jurisdiction over the Canal as a water of the U.S.[24] This AJD letter is included in Appendix C of the federal Aquatic Resources Delineation.

The Canal does not meet the Coastal Act definition of a “wetland” given that: (1) there is no natural water table, commonly understood to mean the upper zone of groundwater saturation,[25] that inundates the Canal, (2) the Canal does not feature hydric soils, but rather is lined by brick and cement, and (3) as stated above, the Canal does not typically support hydrophytes. The Canal is periodically or permanently covered by water only due to its long-term role as a drainage ditch excavated in dry land and incorporated into a stormwater system as a conveyance of stormwater flows, and authorized dry season base flows. While the Canal is located within the Coastal Zone and may be “covered periodically or permanently with shallow water” during such stormwater or base flow conveyance, it is not a resource mapped in the San Francisco LCP, nor does it exhibit any of the characteristics described in the Commission’s wetland

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24 U.S. Army Corps of Engineers (USACE), 2016. San Francisco District, 2016. Approved Jurisdictional Determination (AJD) for the Vista Grande Canal. Letter addressed to Mr. Patrick Sweetland of Daly City Department of Water, prepared by Allen, Aaron O., Acting Chief, Regulatory Division. File Number 2014-00030S. April 29, 2016.

25 https://www.usgs.gov/special-topic/water-science-school/science/aquifers-and-groundwater?qt-science_center_objects=0#qt-science_center_objects

definition. Moreover, as confirmed by the USACE, the Canal does not have significant habitat value, given its low physical and biological functions. Consequently, the Canal is not considered a coastal wetland.

California Blackberry Thicket and Arroyo Willow Scrub Uplands

During the 2020 survey, wetland ecologists investigated areas mapped as hydrophytic vegetation communities within the CCC study are. All of the hydrophytic vegetation communities along Lake Merced, as described above, were considered potential coastal wetlands.

Two additional areas adjacent to the banks of the Vista Grande Canal contain hydrophytic vegetation communities, but were determined to be upland based on their lack of hydric soils and hydrology indicators. These two areas include California blackberry thickets and arroyo willow scrub.[26]

California blackberry thickets are present in upland areas east and northeast of the Vista Grande Canal. They are dominated by California blackberry (FAC), fiddleneck (*Amsinckia* sp.; UPL), California figwort (*Scrophularia californica*; FAC), and wild radish (*Raphanus sativus*; UPL) in the shrub layer and mostly non-native upland grasses and herbs in the understory. California blackberry and California figwort are classified as FAC – plants that are equally likely to occur in wetlands or non-wetlands. Arroyo willow is classified as a FACW plant, which usually occurs in wetlands, but sometimes may occur in uplands. These classifications indicate the probability of a species occurring within a wetland, rather than that such species are always considered hydrophytes. Sample points SP14, SP15, SP16, and SP17 were taken within the California blackberry thickets. Per the USACE definition, wetland vegetation was present at sample points SP15 and SP17. However, hydric soils and wetland hydrology indicators were absent from all sample points.

Sample point SP18 was taken within the arroyo willow scrub located at the northern end of the Vista Grande Canal within the CCC study area. It was dominated by arroyo willow (FACW) and California blackberry (FAC). However, again, hydric soils and wetland hydrology indicators were absent from this sample point.

Per the Commission's regulations, an area must be "land where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes," to be classified as wetland. However, hydric soil and wetland hydrology indicators were absent from the areas adjacent to the Vista Grande Canal. Furthermore, there was no topographical indication that these areas could support water collection and there was no apparent hydrological connection to water within the Vista Grande Canal – an artificial stormwater channel that does not support any riparian habitat given the presence of steep and impervious banks that prevent establishment of hydrophytes. California blackberry thickets and arroyo willow scrub occur several feet higher than the OHWM of the Canal. Given these observations, the California blackberry thickets and arroyo willow scrub located in uplands adjacent to the Vista Grande Canal are not considered coastal wetlands under the jurisdiction of the Commission.

[26] See Figures 7 through 10 for the extent of these vegetation communities along the Canal.

Project Impacts to Coastal Waters

Construction

Project impacts are summarized in **Table 2** and detailed by Project component in **Table 3**. **Figures 5** through **13**, located at the end of the memorandum, depict temporary and permanent Project impacts to CCC regulated coastal waters, including wetlands and open waters. Impacts of Project components are discussed below in the following subsections.

In summary, implementation of the Project would result in permanent impacts to a total of approximately 0.137 acre of coastal waters within the Pacific Ocean and Lake Merced (this includes 0.013 acre of emergent wetland, 0.063 acre of arroyo willow wetland, and 0.061 acre of open water). Temporary construction-related impacts would total approximately 0.651 acres of coastal waters within the Pacific Ocean and Lake Merced (this includes 0.128 acre of emergent wetland, and 0.276 acre of arroyo willow wetland, and 0.260 acre of open water).

TABLE 2
OVERVIEW OF TEMPORARY AND PERMANENT IMPACTS TO COASTAL WATERS BY AQUATIC RESOURCE TYPE

CCC-Regulated Aquatic Resource Type	Temporary Impact (acre)	Permanent Fill (acre)
Emergent Wetlands	0.128*	0.013
Arroyo Willow Wetlands	0.276*	0.063
Open Waters	0.260	0.061
Total Impacts to Coastal Waters	**0.651****	**0.137*****

NOTES:
* Total includes impacts associated with the PRGC Staging Area option (among two under consideration – Options A and B) with the greatest impact per wetland type to calculate greatest potential impact to those respective wetland types. Option A would have a greater impact on arroyo willow wetlands and Option B would have a greater impact on emergent wetlands. (see Figure 7, Table 3 (below) and Section 2.3.2 in the CDP Application Supplement for additional discussion of PRGC staging options).
** Total includes 0.030 acre impacts from PRGC staging area Option B since this option would result in greater total impacts to CCC-regulated wetlands.
*** Total accounts for removal of 0.006 acre of fill from the Pacific Ocean associated with the existing Ocean Outlet.

Ocean Outfall and Submarine Outlet Pipe

As described under the Results Section, the limits of coastal waters jurisdictional to the Commission for the Pacific Ocean were determined using the MHTL of 5.29 feet NAVD88 NOAA tidal datum elevation for Ocean Beach. Coastal waters of the Pacific Ocean would be impacted temporarily during replacement of the submarine outfall pipe, installation of a sheet pile cofferdam to isolate the Ocean Outlet work area, during demolition of the existing outlet and construction of the replacement outlet structure, new concrete apron, wing walls, and placement of riprap at the wing walls. Minimal permanent impacts to coastal waters would be associated with the replacement outlet structure due to the net decrease in fill associated with the existing structure.

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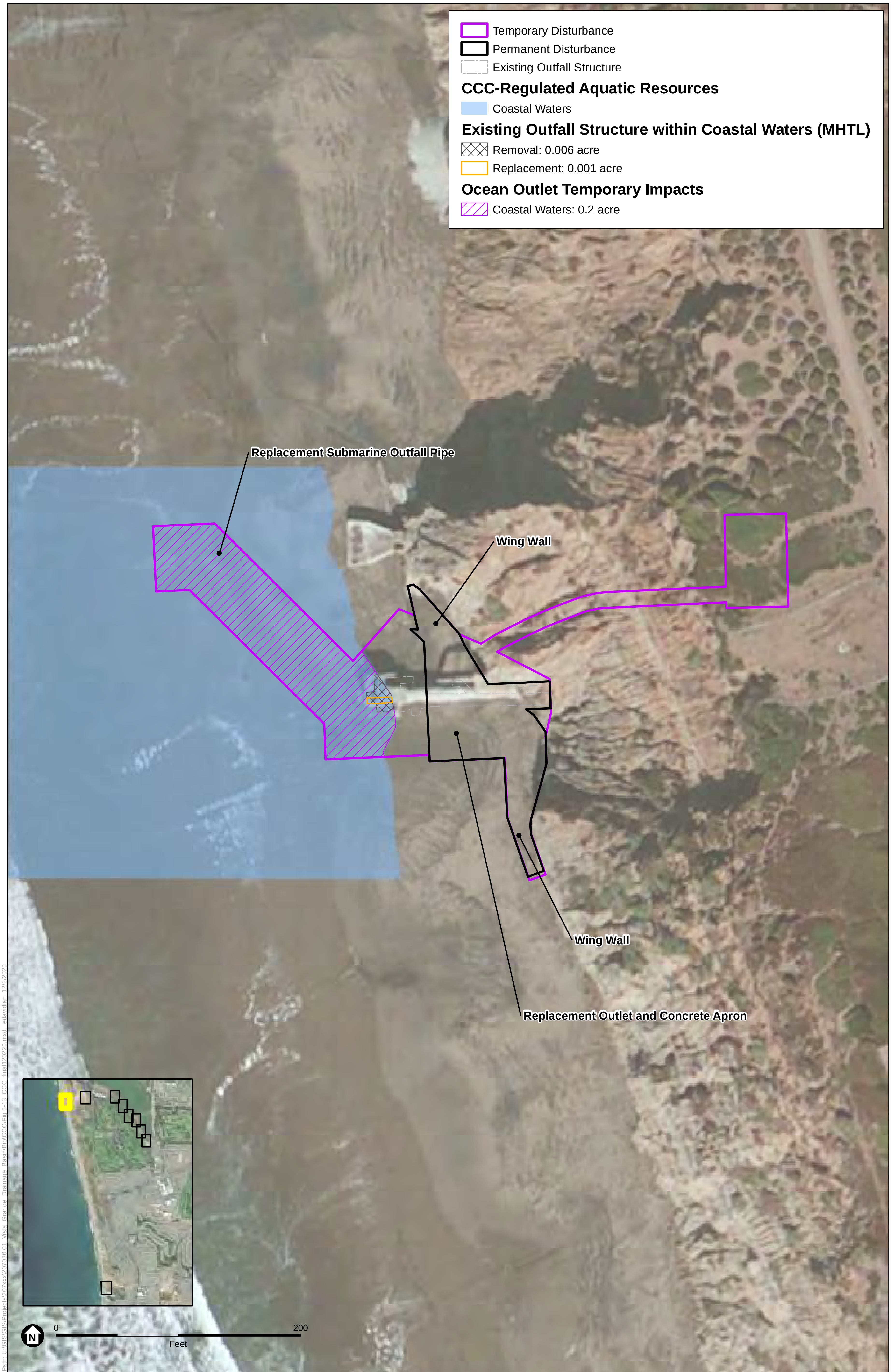
TABLE 3
IMPACTS TO CCC-REGULATED COASTAL WATERS IN THE PROJECT BOUNDARY

Project Site/ Project Component	Description of Work in CCC-regulated Aquatic Resources	Temporary Impacts				Permanent Fill			
		Open Water (acre)	Emergent Wetlands (acre)	Arroyo Willow Wetlands (acre)	Total Temporary Impacts (acre)	Open Water (acre)	Emergent Wetlands (acre)	Arroyo Willow Wetlands (acre)	Total Permanent Impacts (acre)
Pacific Ocean									
Ocean Outlet	Replacement of the existing ocean outlet structure and a portion of the existing 33-inch submarine outfall pipeline that crosses the beach at Fort Funston. A sheet pile cofferdam will be installed around the temporary work area on the beach during construction. Work includes demolishing and removing the existing outlet and exposed portions of the existing Tunnel; creating the new portal structure and installing the new outlet structure of cast-in-place concrete; removing the 27-inch force main; connecting the new 33-inch welded steel pipeline to the existing submarine outfall pipeline and inserting concrete pier support structures; installing the wing walls and concrete apron.	0.200	-	-	**0.200**	0.001	-	-	**0.001**
	Removal of the existing Ocean Outfall structure from the Pacific Ocean outside of the footprint of the replacement structure, constituting removal of fill from coastal waters.	-	-	-	**-**	-0.006	-	-	**-0.006**
Avalon Canyon Access Road	Removal of a portion of the slope inside the curve of the existing road to accommodate the new grade of the road; or stabilization of the road with a small tie-back and lagging wall. In addition, sand would need to be placed over the existing riprap on the beach at the base of the road (the Avalon Canyon access road beach terminus) to allow vehicles and equipment to drive over the riprap to access the beach. **Work is located above the mean high tide line in upland areas; therefore, no impacts to coastal waters are anticipated.*	-	-	-	**-**	-	-	-	**-**
Lake Merced									
Overflow Structure	Modification of the existing Lake Merced overflow structure in South Lake, which connects Lake Merced to the Vista Grande Canal, to include a siphon which allows water from the Lake to flow into the Canal and Tunnel. Work includes clearing of riparian vegetation within the temporary work area; installation of a temporary cofferdam and dewatering the work area; demolishing a portion of the existing overflow structure; constructing the overflow extension into the lake; and installing the adjustable height weir and flexible pipeline (siphon).	0.006	0.094	0.150	**0.250**	-	-	-	**-**
	The overflow extension consists of a flexible pipeline that would float suspended above the lake bottom, weighted in place with 63 precast concrete anchors spaced 10 feet apart (each anchor totaling 22.5 square feet) which would sit on the lake bottom within open waters of South Lake. The end of the pipe would be fitted with a fish screen, supported by a precast concrete slab (126 square feet), also on the lake bottom.	-	-	-	**-**	0.036	-	-	**0.036**
PRGC Staging Area Options	The PRGC site would be used for assembly of the overflow structure's flexible pipeline, and associated construction staging. Once assembled, the pipeline would be pulled into the Lake and connected to the overflow structure. Either option (Option A or Option B) would result in temporary impacts to CCC-regulated wetlands. Option A	-	-	0.030	**0.030**	-	-	-	**-**
	Option B	-	0.013	0.006	**0.019**	-	-	-	**-**
Wetland Pump	A pump would be placed in the bank of South Lake to move water from the lake to the flexible pipeline extending between South Lake and the treatment wetlands. The flexible pipe would float on the lake surface, but would be tethered to a precast anchor.	0.014	-	-	**0.014**	-	-	-	**-**
Outlet Structure	Construction of the Lake Merced Outlet Structure within Impound Lake would require clearing of riparian and wetland vegetation; installation of a temporary sheet pile cofferdam and dewatering the work area; excavation of the box culvert footprint within the bank.	0.040	0.021	0.096	**0.157**	0.030	0.013	0.063	**0.106**
	Total Impacts to Coastal Waters	**0.260**	**0.128***	**0.276***	**0.651****	**0.061**	**0.013**	**0.063**	**0.137*****

NOTES:
* Total includes impacts associated with the PRGC Staging Area option with the greatest impact per wetland type to calculate greatest potential impact to those respective wetland types. Option A would have a greater impact on arroyo willow wetlands and Option B would have a greater impact on emergent wetlands.
** Total includes 0.030 acre impacts from PRGC staging area Option B since this option would result in greater total impacts to CCC-regulated wetlands.
*** Total accounts for removal of 0.006 acre of fill associated with the existing Ocean Outlet.

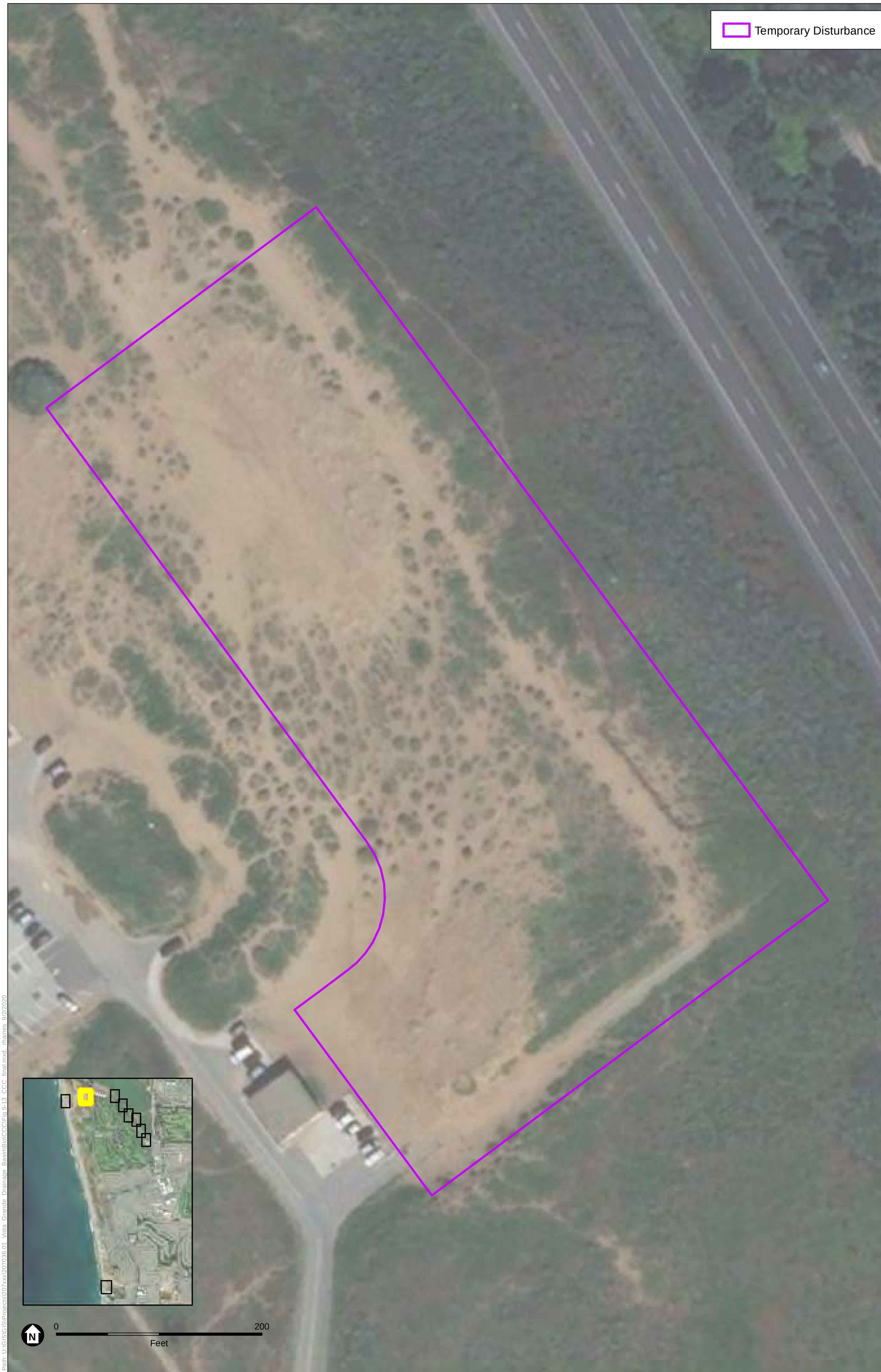


SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

ESA

Figure 5
Project Impacts to Coastal Commission Regulated Aquatic Resources

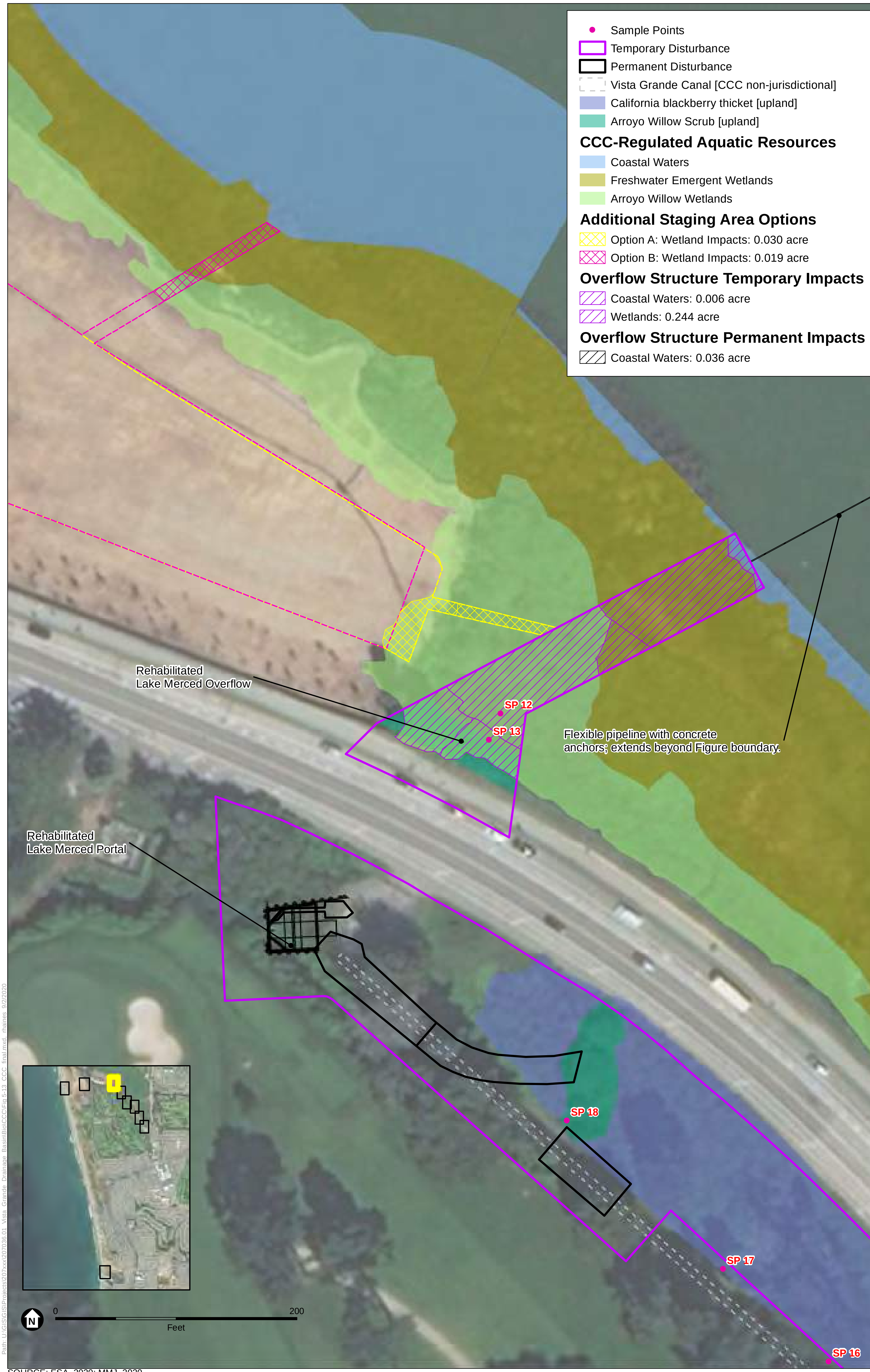


SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

Figure 6
Project Impacts to Coastal Commission Regulated Aquatic Resources

ESA



SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

Figure 7
Project Impacts to Coastal Commission Regulated Aquatic Resources

ESA

SOURCE: ESA, 2020; MMJ, 2020

ESA

Figure 8
Project Impacts to Coastal Commission Regulated Aquatic Resources

SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

Figure 9
Project Impacts to Coastal Commission Regulated Aquatic Resources

ESA

SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

ESA

Figure 10
Project Impacts to Coastal Commission Regulated Aquatic Resources

SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

ESA

Figure 11
Project Impacts to Coastal Commission Regulated Aquatic Resources

SOURCE: ESA, 2020; MMJ, 2020

Vista Grande Drainage Basin Improvement Project | 207036.01

Figure 12
Project Impacts to Coastal Commission Regulated Aquatic Resources

ESA

SOURCE: ESA, 2020; MMJ, 2020

Replacement of the existing Ocean Outfall and partial replacement of the existing submarine outfall pipeline would result in temporary impacts to a total of 0.200 acre of coastal waters as shown in Figure 5. Note that a portion of the existing permanent structure (0.006 acre) within coastal waters would be removed permanently (Figure 5 shown in grey cross hatch). Within that removal area, a segment of the outfall pipeline (0.001 acre) would be replaced (Figure 5, shown in orange outline). Therefore, this removal and replacement of the Ocean Outlet structure and submarine outfall pipe would result in a net removal of 0.005 acre of fill in the form of permanent structures from coastal waters.

During construction, a temporary sheet pile cofferdam would be installed around the work area on the beach within which all demolition and construction activities on the Ocean Outlet would occur. As specified in Mitigation Measure 3.4-8a: Wetland Avoidance and Protection (described under the Mitigation Measures heading below), equipment maintenance and refueling during Ocean Outlet work will be performed in designated upland staging areas and work areas at least 50 feet from jurisdictional waters; all work on the Ocean Outlet will be conducted during periods of low tide, outside the waters of the Pacific Ocean, and when beach conditions provide accessible areas for equipment mobilization and storage beyond the reach of tides. Drip pans and/or liners will be stationed beneath all equipment staged on the beach to minimize spill of deleterious materials into jurisdictional waters and spill kits will be available within the cofferdam for easy accessibility during beach work.

Access to the Ocean Outlet would be along the beach (above the tide) from the Avalon Canyon access road (see Figure 13 and below discussion). Following construction, the cofferdam would be removed and excavated areas surrounding the outlet structure returned to the beach grade.

Avalon Canyon Access Road Improvements

Improvements to the existing road within Avalon Canyon are necessary to facilitate contractor access to the beach and Ocean Outlet during construction. A majority of the road improvements would occur far above the Pacific Ocean jurisdictional boundaries of coastal waters (see Figure 13); however, at the base of the roadway where asphalt transitions to beach, placement of sand on existing riprap is necessary to allow vehicle and equipment access over riprap to the beach. No placement of sand would occur below the MHTL, so no impacts to coastal waters would result from this activity.

Lake Merced Overflow and Outlet Structures

Coastal waters of Lake Merced include the open waters and associated emergent wetlands and arroyo willow wetlands. Temporary and permanent impacts to these aquatic resources would occur at the overflow structure at South Lake and the PRGC site, pump, and box culvert and outlet structure at Impound Lake.

Rehabilitation of the overflow structure in South Lake would include an extension of the flexible pipe siphon into open water, weighted by anchors, and fitted with a fish screen. Permanent impacts associated with 63 precast concrete anchors on the lake bottom and the precast concrete slab to support the fish screen would result in permanent impacts to a total of 0.036 acre of coastal (open) waters. Installation of the box culvert and outlet structure into Impound Lake would result in permanent impacts to a total of 0.106 acre of coastal waters (which includes 0.030 acre of open water, 0.013 acre of emergent wetland, and 0.063 acre of arroyo willow wetland). Impacts to coastal waters associated with these components are shown in Figures 7, 10, and 11.

Temporary impacts associated with rehabilitation of the overflow structure (in South Lake), placement of the wetland pump (in South Lake), and construction of the outlet structure (in Impound Lake) would result in cumulative temporary impacts to 0.421 acre of coastal waters (consisting of 0.060 acre of open water, 0.115 acre of emergent wetlands, and 0.246 acre of arroyo willow wetland). If PRGC staging area option A is used, temporary impacts to 0.030 acre of coastal waters (arroyo willow wetland) would result. If PRGC staging area option B is used, temporary impacts to 0.019 acre coastal waters (0.013 acre emergent wetlands and 0.006 acre arroyo willow wetlands) would result.

Rehabilitation of the overflow structure (South Lake) connecting the Vista Grande Canal to Lake Merced and construction of the outlet structure (Impound Lake) and will require removal of existing vegetation (primarily riparian though some wetland) within the temporary work areas and where permanent infrastructure associated with the outlet structure is present. Cofferdams and dewatering of the work areas may be necessary at both structure locations. Should cofferdams be necessary, demolition of the existing overflow and construction of the new overflow and outlet structures will occur within the boundaries of the cofferdam. Waters isolated within these cofferdam areas will likely contain high concentrations of sediment as a result of the level of ground disturbance within the isolated work area. Therefore, the adopted MMRP requires the implementation of standard BMPs to remove sediment from the dewatering discharge directed to receiving waters, to control the rate of discharge, and to avoid adverse effects related to runoff, flooding, and damage to adjacent structures. As specified in Mitigation Measure 3.4-8a: Wetland Avoidance and Protection (described under the Mitigation Measures heading below), equipment maintenance and refueling will be performed in designated upland staging areas and work areas at least 50 feet from jurisdictional waters.

Temporary impacts to wetlands and riparian habitat would be restored to pre-Project conditions (contours, topsoil, and vegetation) according to Mitigation Measure 3.4-8b: Compensation for Impacts to Wetlands and Riparian Habitat (described under the Mitigation Measures heading below).

Operation

Lake Level Management and Changes to Shoreline Vegetation

Management of Lake Merced water levels as a part of Project operation would increase WSE above existing conditions (baseline of 6 feet City Datum) to between 6 and 10 feet WSE with the target elevations of 7.5, 8.5, and 9.5 feet City Datum. The increase in open water surface area at Lake Merced would affect composition and extent of existing shoreline vegetation, including the type and distribution of wetlands, based on the target WSE selected. Additionally, increasing lake levels above existing conditions would inundate some sensitive vegetation communities and rare plant populations around the lake depending on the target WSE selected.

A GIS-based analysis was conducted to estimate vegetation response to changes in lake levels over time using vegetation data from 2012[27], topography, bathymetry, slope, and output from hydrologic modeling,

27 This dataset consisted of 2010 GIS data from the Lake Merced Vegetation Mapping Update (Nomad Ecology, 2011) field verified by ESA in 2012.

and 'action rules'[28] to dictate how vegetation would respond.[29] That methodology has been adapted to this Project to analyze vegetation change in response to changing water surface elevations.

Wetlands

To determine the proposed Project's operational effect on wetlands in the Project's Environmental Impact Report/Environmental Impact Statement (EIR/EIS), the threshold of no net loss of wetlands was compared with the simulated Lake Merced lake levels[31] to assess whether wetland impacts would be expected to occur under the Project and Cumulative Scenarios, relative to baseline conditions.

Wetland extent at Lake Merced is determined primarily by water levels and topography, and has moved up slope with the water levels over time,[32] [33] although the capacity for upward migration is not limitless. As lake levels rise to target WSEs, emergent wetlands are expected to follow closely, as would willow riparian scrub; however, relative proportions of the various wetland types are expected to change as they re-establish and reconfigure in response to the target WSE, depending on topography and adjacent plant communities. The amount of shoreline available for wetland establishment at a given water surface elevation differs according to the topography of the lakeshore, which generally is steeper at higher elevations and flatter at lower elevations.

The GIS-based analysis predicted vegetation changes for increasing water levels compared to baseline.

Overall, the vegetation change analysis predicts incremental increases in wetlands at average annual WSEs between 7 and 10 feet City Datum. Specifically, the cumulative change in herbaceous wetlands would expand between 7 percent and 47.5 percent with lake level increases between 7 and 10 feet City Datum.

In summary, Project operations would maintain lake levels at an average WSE between 6.5 and 8.5 with a maximum of 9.5 feet City Datum, which would result in a shift in the composition of wetland types along the Lake Merced shoreline. With these shifts, there would be no net loss, but rather a net increase, in wetlands and open waters around Lake Merced.

Mitigation Measures

On December 11, 2017, Daly City certified the Project EIR/EIS, which evaluates potential environmental effects of Project construction and operation, and adopted the accompanying Mitigation Monitoring and

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28 ESA biologists developed action rules for each vegetation type to estimate how vegetation would respond to increases in water surface elevation. For example, bulrush only grows in saturated soils and cannot grow if completely submerged for extended periods of time. The action rules developed for bulrush, therefore, dictate the assumption that bulrush is removed (dies) at depths greater than five feet below the water surface elevation and would establish (grow) at and up to 5 feet below the new water surface elevation.

29 Kennedy/Jenks Consultants, 2012. Assessment of Groundwater-Surface Water Interactions for the Regional Groundwater Storage and Recovery Project and San Francisco Groundwater Supply Project, Task 10.2 Technical Memorandum. Prepared for the San Francisco Public Utilities Commission, May 1, 2012.

31 Kennedy/Jenks Consultants, 2014. Lake Merritt Lake-Level Model Results, Vista Grande Canal Flow Diversion Scenario, K/J 1368006*06. Technical Memorandum. Prepared for the San Francisco Public Utilities Commission, February 26.

32 Stillwater Sciences, 2009. Increased Lake Merced Water Level Impacts on Vegetation, Technical Memorandum. Prepared for the San Francisco Public Utilities Commission, March 11.

33 Nomad Ecology, 2011. Lake Merced Vegetation Mapping Update, Lake Merced Natural Area, City and County of San Francisco, California, Revised Draft. Prepared for San Francisco Public Utilities Commission. May.

Reporting Plan (MMRP), which commits the city to implementing mitigation measures to avoid or minimize the Project's adverse environmental effects. The mitigation measures relevant to aquatic resources regulated by the Commission are included below.

Mitigation Measure 3.4-2a: Worker Environmental Awareness Program Training

A Project-specific Worker Environmental Awareness Program (WEAP) training shall be developed and implemented by a qualified biologist and attended by all Project personnel prior to beginning work onsite. The WEAP training shall generally include but not be limited to education about the following:

a) Applicable State and federal laws, environmental regulations, Project permit conditions, and penalties for non-compliance;

b) Special-status plant and animal species with potential to occur at or in the vicinity of the Project site, avoidance measures, and a protocol for encountering such species including a communication chain;

c) Preconstruction surveys and biological monitoring requirements associated with each phase of work and at each Project site as biological resources and protection measures will vary depending on the land managers (see f, below);

d) Known sensitive resource areas in the Project vicinity that are to be avoided and/or protected as well as approved Project work areas, access roads, and staging areas;

e) Best management practices (BMPs) and their location at various Project sites for erosion control, species exclusion, in addition to general housekeeping requirements; and

f) Specific requirements sanctioned by NPS that the Project must comply with while working on NPS-managed lands, including but not limited to:

    i. Preconstruction surveys for and relocation of terrestrial wildlife prior to grading or vegetation removal at Fort Funston;

    ii. Biological monitoring during Project initiation at each NPS-managed Project location (e.g., Ocean Outlet work area) to identify nearby sensitive biological resources and implement avoidance or protection measures approved by NPS staff;

    iii. Seasonal work restrictions during wildlife breeding, nesting, or migration periods; and

    iv. Work area exclusion methods, communication and relocation protocols if wildlife enters a work area(s) while a biological monitor is not onsite.

Mitigation Measure 3.4-8a: Wetland Avoidance and Protection

Access roads, work areas, and infrastructure shall be sited to avoid and minimize direct and indirect impacts to wetlands and waters to the extent feasible. Where work will occur on the Project adjacent to state and federal jurisdictional wetlands and waters, protection measures shall be applied to protect these features. These measures shall include the following:

1) A protective barrier (such as silt fencing) shall be erected around adjacent wetland or water features to isolate them from Project activities and reduce the potential for incidental fill, erosion, or other disturbance;

2) Signage shall be installed on the fencing to identify sensitive habitat areas and restrict construction activities beyond fenced limits;

3) No equipment mobilization, grading, clearing, storage of equipment or machinery, or similar activity shall occur at the Project site until a representative of Daly City has inspected and approved the wetland protection fencing;

4) Daly City shall ensure that the temporary fencing is continuously maintained until all remediation is completed;

5) Equipment maintenance and refueling in support of Project implementation shall be performed in designated upland staging areas and work areas, and spill kits shall be available onsite. Maintenance activity and fueling must occur at least 50 feet from jurisdictional wetlands and other waters or farther as specified in the Project permits and authorizations; and

6) Installation of the cofferdam around the existing outfall structure on the beach below Fort Funston and all subsequent work outside of the cofferdam once installed shall be conducted during periods of low tide, out of the Pacific Ocean, and when beach conditions provide accessible areas for equipment mobilization and storage beyond the reach of tides. Drip pans and/or liners shall be stationed beneath all equipment staged on the beach to minimize spill of deleterious materials into jurisdictional waters and spill kits shall be available within the cofferdam for easy accessibility during beach work.

A fencing material meeting the requirements of both water quality protection and wildlife exclusion may be used.

Mitigation Measure 3.4-8b: Compensation for Impacts to Wetlands and Riparian Habitat

To offset temporary impacts, restoration to pre-Project conditions (typically including contours, topsoil, and vegetation) shall be conducted, as required by regulatory permits (e.g., those issued by the USACE, RWQCB, CDFW, and/or CCC). To offset unavoidable permanent impacts to jurisdictional wetlands, waters, and to riparian habitat, compensatory mitigation shall be provided as required by regulatory permits. Compensation may include on-site or off-site creation, restoration, or enhancement of jurisdictional resources, or payment into an approved mitigation bank for in-kind habitat credits, as determined by the permitting agencies. Mitigation bank credits, if available, shall be obtained prior to the start of construction. On-site or off-site creation/restoration/enhancement plans must be prepared by a qualified biologist prior to construction and approved by the permitting agencies. Implementation of creation/ restoration/enhancement activities by the permittee shall occur prior to Project impacts, whenever possible, to avoid temporal loss. On- or off-site creation/restoration/enhancement sites shall be monitored by Daly City for at least five (5) years to ensure their success.

Mitigation Measure 3.4-10a: Lake Level Management

The Lake Merced overflow weir in South Lake shall be set at no greater than 9 feet City Datum to prevent lake water surface elevation from exceeding 9 feet City Datum during normal operations to avoid significant effects on wax myrtle scrub, Vancouver rye grassland, and eucalyptus forest. Lake Merced water levels shall be maintained at no more than 9 feet City Datum during normal operations. Should an operating WSE above 9 feet City Datum be selected or an extreme storm event requires temporary storage in Lake Merced that would increase WSE above 9 feet City Datum for more than 14 days (at which time vegetation die-off could occur), Mitigation Measure 3.4-10b is required.

Mitigation Measure 3.4-10b: Compensation for Loss of Sensitive Communities at Lake Merced

a) If 9.5 feet City Datum is selected as the target maximum WSE and Lake Merced water levels are not maintained at or below 9 feet City Datum during normal operations, or a storm event requires storage in Lake Merced that would increase WSE above 9 feet City Datum for more than 14 days for wax myrtle scrub and Vancouver rye grassland or for more than one month for blue gum eucalyptus forest, a resurvey of these sensitive vegetation communities around the Lake Merced shoreline to which a significant impact is predicted to occur (i.e., more than 10 percent loss) shall be performed post-inundation to determine actual percent loss.

   i. The resurvey shall be performed by qualified botanists and document the post-inundation conditions (extent) of the wax myrtle scrub, Vancouver rye grassland, and blue gum eucalyptus around Lake Merced between the new inundation limit (above 9 feet WSE) and 13 feet WSE City Datum. Information on the extent of these sensitive natural communities gathered during this exercise may be applied to subsequent storm events during which WSE exceeds 9 feet WSE or if an operating WSE maintains lake levels above 9 feet WSE, for use in quantifying loss of these sensitive communities at various inundation limits above 9 feet City Datum.

   ii. Surveyors may use a combination of on-the-ground vegetation community and habitat type mapping with an assessment of current aerial imagery for informing cover estimates, similar to the mapping exercise performed in 2012 that informed the vegetation change analysis for this EIR/EIS.

   iii. Once the updated vegetation mapping exercise is complete, the new vegetation polygons shall be compared with the 2012 vegetation polygons to quantify change. The polygon comparison shall also consider the new inundation line, to assess whether or not the change in vegetation communities is attributable to inundation or saturation.

   iv. If the updated mapping exercise and comparison assessment determine impacts to wax myrtle scrub, Vancouver rye grassland, or blue gum eucalyptus are less than 10 percent following inundation above 9 feet WSE, no further mitigation is required.

   v. If the updated mapping exercise and comparison assessment determine impacts to wax myrtle scrub, Vancouver rye grassland, or blue gum eucalyptus vegetation communities are 10 percent or more, an onsite revegetation and restoration plan shall be developed for permanently impacted (inundated/lost) communities and habitat types, as detailed in part b), below.

b) An onsite revegetation and restoration plan shall be prepared to compensate for the affected sensitive vegetation communities and habitat lost (in excess of 10 percent) with a maintained WSE above 9 feet City Datum for 14 days or more for wax myrtle scrub and Vancouver rye grassland and for one month or more for eucalyptus forest. The plan shall be submitted to CDFW and CCC for review and approval, as appropriate. Typical compensation ratios for these communities shall be between 1:1 and 3:1 with native plant replacement quantities that shall be determined by the appropriate permitting agencies. Restoration and revegetation shall take place onsite where possible, and occur above the maximum water surface elevation to be maintained at Lake Merced so that future inundation impacts are avoided, and be implemented in coordination with SFRPD.

i. The revegetation and restoration plan shall be prepared by a qualified restoration ecologist and shall include specifications for seed and propagule[34] collection prior to the commencement of construction and at the appropriate phonological stage to capture reproductive structures of target plants within each affected sensitive vegetation community or habitat type. The restoration ecologist shall coordinate with a local native plant restoration nursery to either store the propagules until planting or grow the plants so that they are ready to plant once construction is complete. Restoration areas shall be monitored to assess re-establishment for 5 years or until total native vegetation cover, composition, and species richness in the restored areas are similar to suitable reference sites.

ii. Individual special-status plants within the affected wax myrtle scrub and Vancouver rye grassland communities shall be mitigated according to the guidelines established in Mitigation Measure 3.4-1, Avoidance, Minimization, and Compensation for Special-Status Plants, items d and f regarding additional compensation location and revegetation and restoration plan performance standard details. Eucalyptus forest communities shall be mitigated according to guidelines established in Mitigation Measure 3.4-6, Implement Tree Protection Measures and Plant Replacement Trees, item 3 regarding appropriate replacement tree types, techniques, and performance standards.

Compensatory Mitigation

The Project has been designed and will be constructed to avoid and minimize impacts to coastal waters to the extent feasible. Furthermore, based on the Project purpose, the Project would improve stormwater drainage and minimize flooding risk and beneficially reuse stormwater for Lake Merced water level management and water quality improvements, while also reducing litter deposition and removing permanent fill to improve recreational access at the beach below Fort Funston. Finally, with Project implementation, management of Lake Merced water levels at a higher WSE is expected to result in a net increase in wetlands (see discussion under the Operation heading), translating to an overall net increase in coastal waters for the Project. These Project improvements translate to net permanent increases in both the quantity and quality of coastal waters.

Temporary construction fill (such as cofferdams or equipment access routes and laydown areas) will be removed following construction. Any impacts to riparian or wetland vegetation during construction within temporary work areas will be restored to pre-construction conditions or better through recontouring and revegetation with native plant species.

Unavoidable permanent impacts to coastal waters (totaling 0.137 acres, which accounts for the removal of 0.006 acres of the existing Ocean Outlet) would be offset by the net increase in wetland habitat that would result from Lake Merced increased shoreline, as well as overall Project benefits to Lake Merced water quality and associated aquatic habitats, the reduction of litter and debris at the Pacific Ocean, and the net removal of permanent fill within the intertidal zone associated with the Ocean Outlet improvements. Consequently, the need for compensatory mitigation is not warranted, as habitat for wildlife would be increased as a result of Project implementation.

[34] A plant structure capable of dispersing from the parent plant and establishing in a new location. Root, rhizome, and stem fragments with buds are common propagules as are bulbs, corms, and tubers. Seeds are also considered propagules.

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Attachment 1.
Vista Grande Drainage Basin Improvement Project - Aquatic Resources Delineation

CITY OF DALY CITY VISTA GRANDE DRAINAGE BASIN IMPROVEMENT PROJECT

Aquatic Resources Delineation, San Francisco and San Mateo Counties, California

Prepared for
City of Daly City

September 2014, rev. July 2020

ESA

CITY OF DALY CITY VISTA GRANDE DRAINAGE BASIN IMPROVEMENT PROJECT

Aquatic Resources Delineation, San Francisco and San Mateo Counties, California

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ACRONYMS AND ABBREVIATIONS USED IN THIS DOCUMENT

CFR	Code of Federal Regulations
cfs	cubic feet per second
City Datum	City of San Francisco elevation datum
CNPS	California Native Plant Society
Corps	United States Army Corps of Engineers
CWA	Clean Water Act
FAC	facultative plant species
FACU	facultative upland plant species
FACW	facultative wetland plant species
GIS	Geographic Information System
GPS	Global Positioning System
HAT	highest astronomical tide
HTL	high tide line
LMP	Lake Management Plan
MHW	mean high water
NI	no wetland indicator assigned (for plants)
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
OBL	obligate wetland plant species
OHWM	ordinary high water mark
Project	Vista Grande Drainage Basin Improvement Project
RHA	Rivers and Harbors Act
SCS	Soil Conservation Service
SFPUC	San Francisco Public Utilities Commission
SWANCC	Solid Waste Agency of Northern Cook County
SWPPP	Storm Water Pollution Prevention Plan
TNW	traditional navigable waters
UPL	upland plant species
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

USFWS	United States Fish and Wildlife Service
WSE	water surface elevation

CHAPTER 1
Introduction

1.1 Objective

This report documents the extent of potentially jurisdictional waters of the United States, including wetlands and other waters, that occur within the Vista Grande Drainage Basin Improvement Project (Project) boundaries, located within the City and County of San Francisco and the City of Daly City, San Mateo County, California (see **Figure 1**).

The purpose of this Aquatic Resources Delineation document is to identify features within the Project delineation study area (i.e., areas that could be directly affected by construction of proposed project components) that may be subject to regulation under Section 404 of the Clean Water Act (CWA), and to provide the background information necessary to support future permit applications under Sections 404 and 401 of the CWA for the Project. The delineation process involves determining the boundaries between wetlands, waters, and surrounding uplands through the investigation of the three parameters that define a wetland: vegetation, soils, and hydrology. This delineation is based on the best professional judgment of ESA investigators. All conclusions presented should be considered preliminary and subject to change pending official review and verification in writing by U.S. Army Corps of Engineers (Corps).

This report has been updated since the version submitted to the Corps for review in September 2014, in order to reflect the Corps' April 2016 determination that the Vista Grande canal is non-jurisdictional (Corps File No. 2014-00030; Approved Jurisdictional Determination [AJD] letter dated April 29, 2016).

This report has also been updated to reflect the current definition of the term 'waters of the United States' in light of: (1) the instatement of the 2015 Clean Water Rule, which went into effect in California in August 2018; (2) the repeal of the 2015 Clean Water Rule, which became effective nationwide in December 2019; and (3) the publication of the 2020 Navigable Waters Protection Rule, which went into effect on June 22, 2020. Lastly, this report includes an additional mapped aquatic feature in the study area resulting from further investigations that took place on July 8, 2020.

SOURCE: Esri, 2013

Vista Grande Drainage Basin Improvement Project . 207036.01

Figure 1
Project Location and Aquatic Resources
Delineation Study Area

1.2 Summary of Results

ESA conducted a formal delineation of all aquatic resources within the delineation study area on November 7 and December 3, 2012. Conditions described in this report were confirmed during a site visit by ESA on October 4, 2018. Further investigations by ESA took place on July 8, 2020. The field delineation efforts identified and documented all aquatic resources within the delineation study area that may be subject to regulation under Section 404 of the CWA. These include: Lake Merced, a freshwater lake used for recreational fishing and boating and thus a Traditional Navigable Water (TNW), and its adjacent wetlands; and the Pacific Ocean below the high tide line (HTL) at Fort Funston. Lake Merced and the Pacific Ocean are subject to jurisdiction under both Section 404 of the CWA and Section 10 of the Rivers and Harbors Act (RHA). Within the overall study area, a total of 18.830 acres (820,254 square feet) of potentially jurisdictional waters of the U.S. may be subject to jurisdiction under Section 404 of the CWA.

CWA; a subset of those waters, totaling 12.372 acres (538,924 square feet), may also be subject to jurisdiction under Section 10 of the RHA.

A detailed summary of all jurisdictional features documented within the delineation study area is presented in Table 3 (see Chapter 4). Delineation maps are presented in Appendix A; wetland datasheets are provided in Appendix B; a preliminary jurisdictional determination analysis map is located in Appendix C; soil maps are provided in Appendix D; the climate summary (WETS Table) information table is provided in Appendix E; and representative photographs are provided in Appendix F.

1.3 Responsible Parties

City of Daly City, Department of Water and Wastewater Resources
Attn: Thomas J. Piccolotti, Director, Project Manager
153 Lake Merced Blvd., Daly City, CA 94015
Phone: (650) 991-8201, e-mail: tpiccolotti@dalycity.org

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CHAPTER 2
Setting

2.1 Delineation Study Area

The delineation study area is located at the southern edge of the City of San Francisco and northern edge of the City of Daly City (Figure 1). The study area is divided into three main study sites: Westlake Park, portions of Lake Merced, and portions of Fort Funston.

The Westlake Park study site is located in Daly City and includes the park and portions of the adjacent Daly City Wastewater Treatment Plant. This study site is bordered on the south by portions of the treatment plant and John Daly Boulevard, on the east by Cliffside Drive, on the north by the Westlake Park parking lot, and on the west by Lake Merced Boulevard. It is entirely developed and surrounded by residential development. The Westlake Park study site is no longer proposed for Project impacts, but has been retained for informational purposes.

The Lake Merced study site includes a western segment of Impound and South Lake, John Muir Drive, and Vista Grande Canal from the confluence of Lake Merced Boulevard and John Muir Drive north to the northern edge of the Olympic Golf Club. This site is surrounded to the north and east by Lake Merced and to the south and west by Olympic Golf Club.

The Fort Funston survey site includes Fort Funston/Golden Gate National Recreation Area north of the Fort Funston Native Plant Nursery to approximately Battery Davis. The Fort Funston survey site also includes the existing City of Daly City and City of San Francisco outlet structures. The Pacific Ocean lies to the west of this site, Lake Merced and Olympic Golf Club to the east, and undeveloped coastline parks to the north and south.

2.2 Climate and Topography

The overall Northern California climate is Mediterranean in nature, with the bulk of precipitation occurring as rain in the winter months. The average annual temperature recorded at the San Francisco Richmond District climatic station is 55.7ºF, while mean annual rainfall is 19.60 inches (USDA, NRCS, 2000).

Topographical elevations within the delineation study area range from sea level to approximately 200 feet above mean sea level (**Figure 2**). The majority of the study area is relatively flat to shallowly sloped. However, steep coastal cliffs approximately 100 feet in height occupy the west edge of the survey area near the Pacific Ocean.

SOURCE: Esri, 2013

Vista Grande Drainage Basin Improvement Project . 207036.01

Figure 2
Project Site Topography

2.3 Soils

The Natural Resources Conservation Service (NRCS) online soil mapping application (USDA, NRCS, 2012) identifies the following soil map units within in the survey area:

- Orthents, cut and fill, 0 to 15 percent slopes
- Rock outcrop-Orthents complex, 30 to 75 percent slopes
- Sirdrak sand, 5 to 50 percent slopes
- Urban land
- Urban land-Orthents, smoothed complex, 5 to 50 percent slopes
- Beaches

A map depicting the soils within the delineation study area is presented in Appendix D. A brief description of each mapped soil unit within the delineation study area follows.

Orthents, cut and fill, are found on alluvial fans, coastal terraces, and hills (USDA SCS, 1991). They are formed from hard or soft sandstone. These soils range from very shallow to very deep and are well drained. In general, these soils have medium runoff and a moderate hazard of water erosion. Much of this soil unit has been cut and filled for golf courses, ball fields, and cemeteries.

Rock outcrop-Orthents complex includes the steep rocky areas and cliffs that occur along the Pacific Ocean (USDA SCS, 1991). This unit includes approximately equal parts rock outcrop and orthents. The rock outcrops include sandstone, shale, and basic igneous rock, and the orthents consist of areas of mixed alluvium, thin loamy soils, and areas of windblown sand.

Sirdrak sand is a deep, somewhat excessively drained soil found on coastal dunes (USDA SCS, 1991). It is formed in aeolian sand with slopes ranging from 5 to 50 percent. Available water capacity in these soils is low and permeability is rapid. This soil unit is often used as recreational areas or wildlife habitat.

Urban land map unit includes areas where 85 percent or more of the surface consists of asphalt, concrete, buildings, or other structures (USDA SCS, 1991). Land uses in this unit include residential and recreational development.

Urban land-Orthents smoothed complex is located on coastal terraces, hills, and ridge tops (USDA SCS, 1991). The majority of this soil unit, 65 percent, consists of urban land, while 25 percent includes orthents, smoothed. The orthents in this unit consist of well-drained soils that have been used for urban development. The orthents are fine sandy loam or loam and formed in soft sandstone of old marine sediment.

According to the National List of Hydric Soils (USDA NRCS, 2011), Sirdrak sand, 5 to 50 percent, may be considered a hydric soil when located on beaches and tidal flats in the Project area. This soil is mapped as occurring at Fort Funston but within an area characterized as coastal dunes and is therefore not considered hydric for the purposes of this delineation. None of the other soils listed as occurring in the delineation study area are considered hydric.

2.4 Hydrology

2.4.1 Vista Grande Drainage Basin

The Basin covers approximately 1,690 acres in the northwestern portion of Daly City and an unincorporated portion of San Mateo County, Broadmoor. The Basin is bounded by the City and County of San Francisco to the north, Colma Creek to the east and south, and the Thornton State Beach/Pacific Ocean to the west. Most of the Basin is composed of densely developed urban areas with a high percentage of impervious surfaces (e.g., roads, roofs, and parking lots), and therefore drains via an underground collection system.

The underground collection system conveys the storm flows to the Vista Grande Canal and then into the Vista Grande Tunnel, which discharges through the Daly City outfall structure into the Pacific Ocean at the beach below Fort Funston. The existing Vista Grande Canal is a 3,600-foot-long man-made brick-lined trapezoidal channel that runs adjacent to the west side of John Muir Drive, paralleling the southwest shores of Lake Merced. The side slopes of the channel are approximately 1:1 and canal dimensions vary from 7 feet deep by 4 feet wide with a flow capacity of 500 cfs to11 feet deep by 11 feet wide with a flow capacity of 900 cfs (RMC, 2006, p. 1-3).

At the terminus of the canal is the inlet of the 3,000-foot-long Vista Grande Tunnel, which has a capacity of 170 cfs. Historically, wet weather flows in excess of the capacity of the canal and the tunnel have occasionally resulted in local flooding and overflows across John Muir Drive into South Lake Merced (RMC, 2006).

2.4.2 Lake Merced

Lake Merced is located in the southwestern corner of San Francisco, bounded by Skyline Boulevard, Lake Merced Boulevard, and John Muir Boulevard, approximately 0.25 mile east of the Pacific Ocean. Lake Merced lies in the San Francisco Coast Watershed and the Westside Groundwater Basin. Lake Merced was historically a lagoon fed by five relatively small streams and groundwater, with occasional connection to the Pacific Ocean via a channel that ran through the current location of the San Francisco Zoo (SFPUC, 2011). Lagoons typically form along the California coast in areas where sand is regularly deposited on beaches and streams only flow during the rainy months. Because the Lake Merced watershed is relatively small and the streams that historically fed it had small watersheds themselves, it was likely rare that flows were great enough to breach the sand bar that blocked them. Beginning in the 1870s the lake was used as a municipal water supply for the City of San Francisco and by the late 1880s the lake was completely separated from the ocean due to construction of Skyline Boulevard and the Great Highway, as well as water diversions for municipal use and urban development. At the same time, berms were constructed to divide the lagoon into four separate lakes: North, East, South, and Impound lakes, collectively known as Lake Merced. However, when lake levels are above 5 feet City Datum, as has been the case since 2006, the lakes are hydrologically connected. South and Impound Lakes lie partially within the delineation study area.

North and South Lakes are hydrologically connected via a culvert and North and East Lakes are connected via a narrow channel under a pedestrian bridge. Impound Lake was formed with the construction of a sewer line and berm across the southern tip of South Lake that restricted the hydrologic connection. Flow between South and Impound Lakes occurs when water levels are above 4.3 feet City Datum.[1]

The total combined surface area of all four lakes has historically ranged from 245 to 273 acres, depending on water level, and total volume of the lakes is approximately 1 billion gallons. South Lake, with a surface area of approximately 175 acres, is the largest of the lakes.

The main sources of inflow to Lake Merced are groundwater interactions, precipitation, stormwater runoff, and manmade additions (**Table 1**). The only physical outlet from Lake Merced is from South Lake via a 30-inch diameter overflow at elevation 13 feet City Datum that connects to the Vista Grande Tunnel immediately downstream of the tunnel connection to the Vista Grande Canal.

TABLE 1
LAKE MERCED SOURCES OF INFLOW AND OUTFLOW

Water Source/Sink	Percent of Total
Inflow	
Precipitation	55
Stormwater	25
Manmade additions	19
Groundwater	1
Outflow	
Evaporation	67
Transpiration	14
Groundwater infiltration	14
Manmade extractions	5

SOURCE: SFPUC, 2011

Water rarely flows from Lake Merced into the Vista Grande Tunnel because water levels within South Lake are rarely at 13 feet City Datum, the level of the overflow outlet. Currently, the

1 Elevations in San Francisco are commonly referenced to three vertical datums, including the North American Vertical Datum of 1988 (NAVD 88), the National Geodetic Vertical Datum of 1929 (NGVD 29), and the San Francisco City Datum (City Datum). NAVD 88 was established in 1991 and is the most up-to-date and accurate datum. NGVD 29 was used by surveyors and engineers for most of the 20th century and is 2.76 feet lower than NAVD 88. The San Francisco City Datum was set at 6.7 feet above the city's former high water mark and is 11.38 feet higher than NAVD 88 and 8.62 feet higher than NGVD 29. Lake Merced water level elevations are typically measured in City Datum.

largest source of outflow is evaporation, followed by transpiration, groundwater infiltration, and manmade extractions.

2.5 Vegetation and Wildlife Habitat

Natural communities are assemblages of plant and wildlife species that occur together in the same area, which are defined by species composition and relative abundance. The study area contains several upland plant communities: developed/landscaped/ruderal, annual grassland, coastal dune scrub, coastal scrub, and arroyo willow riparian scrub. There are three wetland communities within the study area: bulrush and knotweed emergent wetlands and arroyo willow wetland. These communities are described briefly below.

2.5.1 Developed/Landscaped/Ruderal

Developed and landscaped areas within and adjacent to the study area include the Olympic Club Golf Course, Westlake Park, roads and parking lots, and existing facilities. These areas support a variety of ornamental shrubs and trees, with blue gum eucalyptus (*Eucalyptus globulus*), Monterey pine (*Pinus radiata*), and Monterey cypress (*Hesperocyparis macrocarpa*) being the most common trees at Lake Merced and throughout the golf course. Several stands of blue gum and Monterey cypress occur at Fort Funston. Non-native ornamental shrubs are planted in several places on the golf course side of Vista Grande Canal, and Monterey pine and cypress line portions of the canal.

Areas dominated by often temporary assemblages of opportunistic non-native plants that thrive in disturbed areas were characterized as ruderal habitat. Within and adjacent to the study area, this vegetation type occurs adjacent to developed areas such as sidewalks, roads, and golf course edges. Non-native plant species typical of ruderal vegetation in this area include soft chess (*Bromus hordeaceus*), hare barley (*Hordeum murinum* ssp. *leporinum*), ryegrass (*Festuca perennis*), wild radish (*Raphanus sativus*), black mustard (*Brassica nigra*), poison hemlock (*Conium maculatum*), and iceplant (*Carpobrotus edulis*).

Landscaped and ruderal areas can provide cover, foraging, and nesting habitat for a variety of bird species as well as reptiles and small mammals, especially those that are tolerant of disturbance and human presence. Birds commonly found in such areas include non-native species such as English sparrow (*Passer domesticus*) and European starling (*Sturnus vulgaris*) as well as birds native to the area, including American robin (*Turdus migratorius*), house finch (*Carpodacus mexicanus*), and western scrub jay (*Aphelocoma californica*). Other wildlife present in urban landscaped areas include striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), and roosting bats, as well as the non-native Virginia opossum (*Didelphis virginiana*). Red-tailed and red-shouldered hawks (*Buteo jamaicensis; B. lineatus*) prey on Botta's pocket gophers (*Thomomys bottae*) and other small rodents and were observed in the vicinity of Vista Grande Canal and the adjacent golf course during the delineation field study.

2.5.2 Annual Grassland

Annual grassland within the study area occurs on the upper bank of Impound Lake and between Vista Grande Canal and John Muir Drive. Dominant species include non-natives such as ripgut brome (*Bromus diandrus*), wild oats (*Avena fatua*), rattlesnake grass (*Briza maxima*), ryegrass, English plantain (*Plantago lanceolata*), sheep sorrel (*Rumex acetosella*), black mustard, and wild radish. Native herb associates include telegraph weed (*Heterotheca grandiflora*), beach strawberry (*Fragaria chiloensis*), and miniature lupine (*Lupinus bicolor*). Scattered native shrubs are also present, including coyote brush (*Baccharis pilularis*) and dune bush lupine (*Lupinus chamissonis*). Annual grassland at Lake Merced would support a similar set of wildlife species as described above for landscaped areas.

2.5.3 Central Dune Scrub

Central dune scrub is present on the upper banks of South and Impound Lakes, between John Muir Drive and Vista Grande Canal, and at Fort Funston. At Lake Merced, dune scrub vegetation is located in restoration areas managed by the San Francisco Parks and Recreation Department as part of the Significant Natural Areas Program, where dune species have been planted. Dune scrub at Lake Merced is characterized by a mix of dune species with varying cover, including dune bush lupine, yellow bush lupine (*Lupinus arboreus*), coast buckwheat (*Eriogonum latifolium*), coyote brush, coastal sagewort (*Artemisia pycnocephala*), California goldenbush (*Ericameria ericoides*), and lizard-tail (*Eriophyllum staechadifolium*). Characteristic herbs include California acaena (*Acaena pinnatifida* var. *californica*), contorted sun cup (*Camissonia contorta*), and beach evening primrose (*Camissonia cheiranthifolia* ssp. *cheiranthifolia*). Dune scrub within the study area at Fort Funston is affected by recreational uses and has been displaced by iceplant planted to control erosion. Central dune scrub at Lake Merced supports several sensitive, but not federally listed, plant species, including blue coast gilia (*Gilia capitata* subsp. *chamissonis*; CNPS List 1B.1), San Francisco spineflower (*Chorizanthe cuspidata* var. *cuspidata*; CNPS 1B.2), and dune tansy (*Tanacetum camphoratum*; locally rare). Central dune scrub within the study area likely supports western fence lizard (*Sceloporus occidentalis*) and gopher snakes (*Pituophis catenifer*); small rodents such as deer mouse (*Peromyscus maniculatus*), vagrant shrew (*Sorex vagrans*), and California vole (*Microtus californicus*); and a variety of birds including white- crowned sparrow (*Zonotrichia leucophrys*), Bewick's wren (*Thyromanes bewickii*), American robin, common bushtit (*Psaltriparus minimus*), house finch, and mourning dove (*Zenaida macroura*).

2.5.4 Coastal Scrub

Coastal scrub within the study area consists of several different vegetation types classified according to their dominant species, including native California blackberry (*Rubus ursinus*) scrub and coyote brush scrub. Shrubs are dominant in this vegetation type, which may be monotypic, as is generally the case for California blackberry scrub, or supporting a mix of shrubs and herbaceous species. California blackberry scrub occurs in dense thickets between John Muir Drive and Vista Grande Canal and on the banks of South and Impound Lakes at elevations well above the water line; it also occurs with swamp knotweed as a co-dominant. Other herbaceous species are generally lacking due to the dense cover of blackberry. Coyote brush scrub occurs in sandy soils around the lakes and is commonly associated with toyon (*Heteromeles arbutifolia*), lizard-tail, and California coffeeberry (*Frangula californica*), non-native annual grasses, and bracken fern (*Pteridium aquilinum*). Coastal scrub at Lake Merced supports a similar set of wildlife species as described above for landscaped areas, central dune scrub, and annual grasslands.

2.5.5 Willow Scrub

This vegetation community is present on the banks of South and Impound Lakes, forming dense thickets with a continuous canopy of native arroyo willow (*Salix lasiolepis*). Arroyo willow riparian scrub is typically adjacent and upslope from bulrush wetland or swamp knotweed wetland. Some willow scrub at Lake Merced occurs in wetlands and some is considered non-wetland riparian scrub (see Chapter 4 for more details). Additional native species, such as California blackberry, California bulrush (*Schoenoplectus californicus*), swamp knotweed (*Persicaria amphibia*), bracken fern (*Pteridium aquilinum* var. *pubescens*), and California manroot (*Marah fabaceus*) are also present. Arroyo willow riparian scrub at Lake Merced is important habitat for migratory and resident birds, including Townsend's warbler (*Dendroica townsendi*), ruby-crowned kinglet (*Regulus calendula*), green heron (*Butorides virescens*), western kingbird (*Tyrannus verticalis*), and warbling vireo (*Vireo gilvus*).

2.5.6 Freshwater Marsh

Bulrush wetland is the most abundant wetland herbaceous vegetation type mapped at South Lake and Impound Lake and occurs at elevations that remain inundated all to most of the year. Bulrush wetland forms an emergent, almost continuous band along the lake margins. California bulrush is dominant, with swamp knotweed and scattered tules (*Schoenoplectus acutus* var. *occidentalis*) also present. Stinging nettle (*Urtica dioica* ssp. *holosericea*), Pacific rush (*Juncus effusus* var. *pacificus*), and Pacific oenanthe (*Oenanthe sarmentosa*) occur along the upland margins of bulrush wetlands.

Swamp knotweed wetland also occurs along the margins of the lakes, growing as emergent vegetation and often interspersed with bulrush wetland. Swamp knotweed is the dominant species in this community. Similar to bulrush wetlands, associates include California bulrush, stinging nettle, Pacific rush, and Pacific oenanthe. Swamp knotweed has a phenotypic plasticity that allows it to grow in a wide variety of conditions. Within the study area this species can be found in seasonally to permanently inundated wetlands and it also occurs in monotypic stands or mixed with California blackberry in adjacent habitats at higher elevations, where soils may be at least seasonally moist but are never inundated.

The freshwater marshes at Lake Merced support a diversity of wintering and breeding birds including marsh wren (*Cistothorus palustris*), common yellowthroat (*Geothlypis trichas*), pied-billed grebes (*Podilymbus podiceps*), ruddy duck (*Oxyura jamaicensis*), red-winged blackbirds (*Agelaius phoeniceus*), and song sparrows (*Melospiza melodia*). The lake supports numerous non-native red-eared sliders (*Trachemys scripta elegans*) and may also support western pond turtle (*Emys marmorata*), a California Species of Special Concern, which have been observed in East Lake. California red-legged frogs occurred historically at Lake Merced, but the species is now considered extirpated from the lake based on a lack of recent sightings, survey results since 2000, and the presence of predators and competitors, such as bullfrogs and red-eared sliders (San Francisco Planning Department, 2011).

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CHAPTER 3
Methods

3.1 Definitions

Many of the terms used throughout this report have specific meanings with respect to the delineation of waters of the U.S. for the purpose of Section 404 of the CWA, and for navigable waters of the U.S. for the purpose of Section 10 of the RHA. These terms are defined below:

Waters of the United States: The definition of waters of the U.S. subject to federal jurisdiction and concomitant CWA permitting requirements is currently in flux due to U.S. Environmental Protection Agency (USEPA) and Corps (collectively "Agencies") interpretations of that term over the last several years. In 2015, under the Obama administration, the Agencies adopted a revised waters of the U.S. definition (the 2015 Clean Water Rule); then on December 23, 2019, the Trump administration's "Repeal Rule" became effective, repealing the 2015 Clean Water Rule. With the repeal of the 2015 Clean Water Rule, the 1986/1988 definition of waters of the U.S. and accompanying guidance became the operative definition. On April 21, 2020, the Agencies published a new definition of waters of the U.S. in the Federal Register. This new definition, called the 2020 Navigable Waters Protection Rule, is scheduled to become effective on June 22, 2020.

At the time of this report's preparation, the 1986/1988 definition of Waters of the U.S. and accompanying guidance remains in effect. States, municipalities, and non-governmental organizations have brought litigation challenging both the Repeal Rule and the 2020 Navigable Waters Protection Rule, adding to the uncertainty surrounding the scope of water features subject to the CWA and its requirements. We therefore analyze the status of water features within the study area under all three potentially applicable rules.

The Code of Federal Regulations (33 CFR § 328.3[a]; 40 CFR § 230.3[s]) currently defines waters of the United States as:

> (1) All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; (2) All interstate waters including interstate wetlands; (3) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mud flats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which could affect interstate or foreign commerce including any such waters which are or could be used by interstate or foreign travelers for recreational or other purposes; or from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or which are used or could be used for industrial purposes by industries in interstate commerce; (4) All impoundments of waters otherwise defined as waters of the

United States under the definition; (5) Tributaries of waters identified in paragraphs (1) through (4); (6) Territorial seas; and (7) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (1) through (6).

The 2020 Navigable Waters Protection Rule would modify the definition of waters of the U.S. to mean:

(1) The territorial seas, and waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including waters which are subject to the ebb and flow of the tide; (2) Tributaries; (3) Lakes and ponds, and impoundments of jurisdictional waters; and (4) Adjacent wetlands.

Wetlands: The Corps and the USEPA define wetlands as “Those areas that are saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for the life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.” Corps wetlands must typically exhibit three parameters: 1) wetland hydrology, 2) hydrophytic vegetation, and 3) hydric soils in order to meet the federal definition.

Wetland Hydrology: This term encompasses all hydrologic characteristics of areas that are periodically inundated or have soils saturated to the surface at some time during the growing season. These include both riverine and non-riverine hydrology indicators, such as sediment deposits, drift lines, and oxidized rhizospheres along living roots in the upper 12 inches of the soil. In the Arid West, hydrologic indicators may be absent in any given year due to annual variability in precipitation and in times of drought. The *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (Version 2.0) (Arid West Supplement) (Corps, 2008) cites a technical standard that can be used for disturbed or problematic sites that support wetland vegetation and soils but where wetland hydrology is not apparent. This standard calls for 14 or more consecutive days of flooding, ponding, or a water table 12 inches or less below the soil surface during the growing season at a minimum frequency of 5 years in 10.

Hydrophytic Vegetation: Hydrophytic vegetation is defined as plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present. Emphasis is placed on the assemblage of plant species that exert a controlling influence on the character of the plant community, rather than on a single indicator species, i.e., there must be a prevalence of hydrophytic vegetation present in order to satisfy this wetland parameter.

***Wetland Indicator Status*:** Refers to the probability that a plant will occur in a wetland or not. Indicator status categories are as follows:

- *Obligate (OBL)*: almost always occurs in wetlands
- *Facultative wetland (FACW)*: usually occurs in wetlands, sometimes may occur in uplands
- *Facultative (FAC)*: equally likely to occur in wetlands or nonwetlands
- *Facultative upland (FACU)*: usually occurs in uplands but may occasionally occur in wetlands

- *Obligate upland (UPL)*: almost never occurs in wetlands
- *No indicator (NI)*: no indicator assigned due to lack of information

> **Hydric Soil:** A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. Hydric soils are often characterized by redoximorphic features (such as redox concentrations, formerly known as mottles), which form by the reduction, translocation, and/or oxidation of iron and manganese oxides. Hydric soils may lack hydric indicators for a number of reasons. In such cases the same standard used to determine wetland hydrology when indicators are lacking can be used.

Other Waters: In this document, "other waters of the U.S." refers to those hydric features that are regulated by the CWA but are not wetlands (33 CFR § 328.4). The term "other waters of the United States" includes water bodies, such as rivers and streams, that exhibit evidence of an OHWM (defined below) and waters that are navigable or are hydrologically connected to a navigable water body (33 CFR § 328.3[a]; 40 CFR § 230.3[s]). Some types of other waters, such as non-navigable tributaries that are not relatively permanent, must have a significant nexus to a navigable water body to be considered jurisdictional by the Corps pursuant to guidance applicable to the currently effective definition of waters of the U.S., which was first adopted in 1986/1988 and reinstated in December 2019.

Navigable Waters of the United States: The Code of Federal Regulations (33 CFR § 329.4) defines navigable waters of the U.S. as:

> …those waters subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or destroy navigable capacity.

Traditional Navigable Waters: Traditional navigable waters include all of the "navigable waters of the United States" as defined in 33 CFR § 329.4 as well as by numerous decision of the federal courts; those water bodies the Corps has determined are navigable waters of the U.S. pursuant to 33 CFR § 329.14; plus all other waters that are navigable-in-fact. The definition of "navigable-in-fact" comes from a long line of court cases originating with Daniel Ball, 77 U.S. 557 (1870).

Significant Nexus: This term refers to the jurisdictional test established in Justice Kennedy's concurring opinion in *Rapanos v. United States*, 547 U.S. 715 (2006) ("*Rapanos*") and applicable to certain non-navigable tributaries and wetlands adjacent thereto. Following publication of the *Rapanos* decision, USEPA and the Corps issued guidance regarding the appropriate application and scope of the Significant Nexus test. The Significant Nexus test was expanded upon and codified through adoption of the 2015 Clean Water Rule. However, the test was eliminated through adoption of the 2020 Navigable Waters Protection Rule..

Ordinary High Water Mark: OHWM is defined in 33 CFR § 328.3[e] as "…that line on the shore established by the fluctuations of water and indicated by physical characteristics, such as a clear, natural line impressed on the bank, shelving, changes in the character of the soil, destruction of terrestrial vegetation, the presence of litter or debris, or other appropriate means that consider the characteristics of the surrounding area."

Mean High Water: Section 10 of the RHA, which regulates certain activities in navigable waters of the U.S., defines the landward limit of Section 10 jurisdiction as the Mean High Water (MHW) mark. The MHW mark, with respect to ocean and coastal waters, is defined as:

> The line on the shore established by the average of all high tides. It is established by survey based on available tidal data (preferably averaged over a period of 18.6 years because of the variations in tide). In the absence of such data, less precise methods to determine the mean high water mark are used, such as physical markings, lines of vegetation or comparison of the area in question with an area having similar physical characteristics for which tidal data are readily available.

With respect to inland navigable waters such as lakes, rivers, and streams, the landward limit of Section 10 jurisdiction of the RHA relies upon the OHWM (defined above).

High Tide Line: Section 404 of the CWA, which regulates certain activities in waters of the U.S., defines the landward limit of Section 404 jurisdiction as the High Tide Line (HTL) in tidal waters. When adjacent wetlands are present, the limit of jurisdiction extends to the limit of the wetland. HTL is defined as:

> …a line or mark left upon tide flats, beaches, or along shore objects that indicates the intersection of the land with the water's surface at the maximum height reached by a rising tide. The high tide line may be determined by tidal gages, physical markings or characteristics, vegetation lines, a more or less continuous deposit of fine shell or debris on the foreshore or berm, or other suitable means such as a line of oil or scum along the shore that delineate the general height reached by a rising tide. The term includes spring high tides and other high tides that occur with periodic frequency, but does not include storm surges in which there is a departure from the normal or predicted reach of the tide due to the piling up of water against a coast by strong winds such as those accompanying a hurricane or other intense storm.

Growing Season: The growing season is that part of the year when soil temperatures at 19.7 inches below the soil surface are higher than biologic zero (5°C/41° F). Growing season dates should be determined through onsite observations whenever possible. Since onsite data gathering is often not possible, growing season dates can be approximated by using WETS tables from the nearest appropriate WETS station. The WETS table 70 percent probability average beginning and ending dates for 28° F temperatures can be used to represent the "normal" growing season for wetland determinations (NRCS, 1995). According to the San Francisco WETS Station data (see Appendix E) the normal growing season for the study area would be 365 days (USDA, NRCS, 2000).

3.2 Regulatory Setting

3.2.1 Rivers and Harbor Act of 1899

Section 10 of the Rivers and Harbors Act (RHA) (33 U.S.C. § 403) requires authorization from the Corps for work or structures in or affecting navigable waters of the U.S. The term “navigable waters of the U. S.” generally includes those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or destroy navigable capacity (33 C.F.R. §329.4).

Section 14 of the RHA of 1899 (33 U.S.C. § 408), commonly referred to as “Section 408,” authorizes the Corps to grant permission to alter, occupy, or use a Corps civil works project if the Secretary determines that the activity will not be injurious to the public interest and will not impair the usefulness of the project.

3.2.2 Clean Water Act

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The basis of the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act, but the Act was significantly reorganized and expanded in 1972. "Clean Water Act" became the Act's common name with amendments in 1972.

In 1986, the term “waters of the United States” was defined as follows (33 CFR 328.3[a]):

(1) All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;

(2) All interstate waters including interstate wetlands;

(3) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:

- (i) Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
- (ii) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
- (iii) Which are used or could be used for industrial purpose by industries in interstate commerce;

(4) All impoundments of waters otherwise defined as waters of the United States under the definition;

(5) Tributaries of waters identified in paragraphs (a)(1) through (4) of this section;

(6) The territorial seas; and

(7) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a)(1) through (6) of this section.

(8) Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other Federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with EPA.

Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.11(m) which also meet the criteria of this definition) are not waters of the United States

Wetlands (including swamps, bogs, seasonal wetlands, seeps, marshes, and similar areas) are also considered waters of the U.S. (subject to the significant nexus test), and are defined by the Corps as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (33 CFR 328.3[b]; 40 CFR 230.3[t]). Indicators of three wetland parameters (i.e., hydric soils, hydrophytic vegetation, and wetlands hydrology), as determined by field investigation, must be present for a site to be classified as a wetland by the Corps (Environmental Laboratory 1987).

Section 401 of the CWA gives the state authority to grant, deny, or waive certification of proposed federally licensed or permitted activities resulting in discharge to waters of the U.S. The State Water Resources Control Board (State Water Board) directly regulates multi-regional projects and supports the Section 401 certification and wetlands program statewide. The Regional Water Quality Control Board (RWQCB) regulates activities pursuant to Section 401(a)(1) of the federal CWA, which specifies that certification from the State is required for any applicant requesting a federal license or permit to conduct any activity including but not limited to the construction or operation of facilities that may result in any discharge into navigable waters. The certification shall originate from the State or appropriate interstate water pollution control agency in/where the discharge originates or will originate. Any such discharge will comply with the applicable provisions of Sections 301, 302, 303, 306, and 307 of the CWA.

Status of the Waters of the U.S. Definition

In 2015, the Corps and the USEPA issued the 2015 Clean Water Rule detailing the process for determining CWA jurisdiction over waters of the United States. The rule never became effective in all 50 states because the Sixth Circuit Court of Appeals issued a nationwide stay of the rule. *In re EPA & Dep’t of Def. Final Rule*, 803 F.3d 804 (6th Cir. 2015). In 2018, the U.S. Supreme Court found that the Sixth Circuit lacked primary jurisdiction over review of the regulation, paving the way for the 2015 Clean Water Rule to become effective in California and several other states for a short time. On October 22, 2019, the Corps and USEPA published a notice in the federal register repealing the 2015 Clean Water Rule. The repeal became effective on December 23, 2019, at which time the previously in effect definition of waters of the U.S. and associated guidance became effective again. This previously in effect definition dates back to 1986/1988 and includes subsequent guidance including the Significant Nexus test outlined in *Rapanos v. United States*. On April 21, 2020, the Agencies published in the Federal Register a revised definition of waters of the U.S. (the Navigable Waters Protection Rule), which is currently scheduled to become effective on June 22, 2020. However, recent litigation presents some uncertainty as to when and whether the Navigable Waters Protection Rule will ultimately become effective, and whether the Repeal Rule will stand. For this reason, we delve into the regulatory issues analyzing jurisdiction under all three scenarios (the 1986/1988, 2015, and 2020 rules).

2015 Clean Water Rule

The 2015 Clean Water Rule includes a detailed process for determining which areas may be subject to jurisdiction under the CWA, and broadly classifies features into three categories: those that are jurisdictional by rule (Category A below), those that are excluded by rule (Category C below) and those features that require application of a case-specific “significant nexus test” to determine jurisdictional status (Category B below).

The 2015 Clean Water Rule’s significant nexus test includes consideration of hydrologic and ecologic factors. For those features encompassed by Category B, the significant nexus test would take into account: (1) a water feature’s hydrologic relationship to TNWs, certain wetlands, and other waters of the U.S.; and (2) whether the aquatic functions of the water feature have a significant effect (more than speculative or insubstantial) on the chemical, physical, and biological integrity of a TNW. The Corps and USEPA will apply the 2015 Clean Water Rule’s significant nexus standard to assess the flow characteristics and functions of a potential water of the U.S. to determine if they significantly affect the chemical, physical, and biological integrity of the downstream TNW.

2015 Clean Water Rule Key Points Summary

(A) The Corps and EPA will assert jurisdiction over the following waters (jurisdictional by rule):

- Traditional Navigable Waters.
- Interstate waters and wetlands.
- Territorial seas.
- Impoundments of waters (reservoirs, etc.).
- Tributaries with the following attributes:
  - Contributes flow either directly or through another water to a TNW, territorial sea, or interstate water (including interstate wetlands).
  - Contain bed, banks, and ordinary high water mark.
  - Can be natural, man-altered, or man-made.
  - Can have constructed breaks (culverts, pipes, etc.) or natural breaks.
- Waters “adjacent” to a (1) TNW, (2) territorial sea, (3) interstate water (including interstate wetlands), (4) tributaries to waters classified under categories (1) – (3), and (5) impoundments of jurisdictional waters, including:

- Adjacent wetlands, ponds, lakes, oxbows, impoundments of jurisdictional waters, and similar waters.
- Waters that are bordering, contiguous, or neighboring a (1) TNW, (2) interstate water (including wetlands), (3) territorial sea, (4) tributaries to waters classified under categories (1) – (3), and (5) impoundments of jurisdictional waters, including waters separated from other jurisdictional waters by constructed dikes or barriers, natural river berms, beach dunes or similar.
- Waters that connect segments of a (1) TNW, (2) interstate water (including wetlands), (3) territorial sea, (4) tributaries to waters classified under categories (1) – (3), and (5) impoundments of jurisdictional waters.
- Waters that are located at the head water of a (1) TNW, (2) interstate water (including wetlands), (3) territorial sea, (4) tributaries to waters classified under categories (1) – (3), and (5) impoundments of jurisdictional waters, and are bordering, contiguous, or neighboring such waters.
- Waters within 100 feet of the OHWM of a (1) TNW, (2) interstate water (including wetlands), (3) territorial sea, and (4) tributaries to waters classified under categories (1) – (3), and (5) impoundments of jurisdictional waters.
- Waters within the 100-year floodplain and within 1,500 feet of a (1) TNW, (2) interstate water (including wetlands), (3) territorial sea, (4) tributaries to waters classified under categories (1) – (3), and (5) impoundments of jurisdictional waters.
- Waters within 1,500 feet of the HTL or OHWM of a TNW or territorial sea.

(B) The Corps and EPA will decide jurisdiction over the following waters based on a fact-specific analysis to determine whether they have a significant nexus with a TNW, interstate water (including wetlands), or territorial sea unless excluded by rule (significant nexus test):

- Vernal pools that when alone or in combination with other similarly situated waters have a significant nexus to a TNW, interstate water (including wetlands), or territorial sea.
- Waters and wetlands within the 100-year floodplain of a TNW, interstate water (including wetlands), or territorial sea that when alone or in combination with other similarly situated waters have a significant nexus to a TNW, interstate water (including wetlands), or territorial sea.
- Waters and wetlands within 4,000 feet of the HTL or OHWM of a (1) TNW, (2) interstate water (including wetlands), (3) territorial sea, (4) tributaries to waters classified under categories (1) – (3), and (5) impoundments of jurisdictional waters that when alone or in combination with other similarly situated waters have a significant nexus to a TNW, interstate water (including wetlands), or territorial sea..

(C) The USACE and EPA will not assert jurisdiction over the following features (excluded by rule):

- Waste treatment systems, including treatment ponds, designed to meet the requirements of the CWA.

- Prior converted cropland.
- The following types of ditches:
  - Ephemeral ditches that are not a relocated tributary or excavated in a tributary.
  - Ditches with intermittent flow that are not a relocated tributary, excavated in a tributary, or drain wetlands.
  - Ditches that do not flow, either directly or through another water, into a TNW, interstate waters (including wetlands), territorial sea.
- Artificially irrigated areas that would revert to upland if application of water ceased.
- Artificial, constructed lakes and ponds created in dry land such as stock watering ponds, irrigation ponds, settling basins, fields flooded for rice growing, cooling ponds
- Swimming pools or reflecting pools in dry land.
- Small ornamental waters created in dry land.
- Water-filled depressions created in dry land, which are incidental to mining or construction activities, including pits for obtaining fill, sand, or gravel.
- Erosional features including gullies, rills, and other ephemeral features that are not tributaries, non-wetland swales and lawfully constructed grass waterways.
- Puddles.
- Groundwater.
- Stormwater control features constructed to convey, treat, or store stormwater, which are created in dry land.
- Wastewater recycling structures created in dry land including detention and retention basins, groundwater recharge basins, percolation ponds and water distributary structures.

1986/1988 Rule (2019 Repeal Rule)

As previously discussed, on October 22, 2019, the Corps and USEPA published a notice in the Federal Register repealing the 2015 Clean Water Rule. The repeal became effective on December 23, 2019, at which time the previously-in-effect 1986/1988 waters of the U.S. definition and associated guidance became effective again. Following publication of the Repeal Rule, one trade association and eleven (11) environmental groups filed two separate complaints challenging the rule in two differing federal district courts, presenting additional uncertainty regarding the scope of waters of the U.S.

This currently applicable definition sets forth certain waters considered jurisdictional by rule (Category A), and codifies certain exemptions from the definition of waters of the U.S. (Category B). The 1986 and 1988 preambles to the currently applicable definition of waters of the U.S. identify additional water features over which the Corps and USEPA do not generally assert jurisdiction, but over which the Agencies reserve the right to assert jurisdiction on a case-by-case basis (Category C). Although the clarifications provided in the preamble to the Corps' 1986 definition of waters of the U.S. were not reduced to a formal regulation, courts have generally deferred to Corps' interpretation of its own regulations. (*Northern California River Watch v. City of Healdsburg*, 2004 WL 201502, at *12-13 (N.D. Cal. 2004).) Further, USEPA noted the same exclusions in the preamble to regulations it subsequently issued in 1988. (53 Fed. Reg. 20765 (June 6, 1988).)

(A) The Corps and USEPA will assert jurisdiction over the following water features considered to be waters of the U.S.:

> (1) All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
>
> (2) All interstate waters including interstate wetlands;
>
> (3) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which could affect interstate or foreign commerce including any such waters:
>
> > (i) which are or could be used by interstate or foreign travelers for recreational or other purposes; or
> >
> > (ii) from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
> >
> > (iii) which are used or could be used for industrial purposes by industries in interstate commerce;
>
> (4) All impoundments of waters otherwise defined as waters of the United States under the definition;
>
> (5) Tributaries of waters identified in paragraphs (1) through (4);
>
> (6) Territorial seas; and
>
> (7) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (1) through (6).

(B) USEPA and the Corps do not consider the following water features to be waters of the U.S. based on codified exemptions:

> (1) Waste treatment systems, including treatment ponds, designed to meet the requirements of the CWA.
>
> (2) Prior converted cropland.

(C) USEPA and the Corps do not consider the following waters to be waters of the U.S., but will consider their jurisdictional status on a case-by-case basis:

> (1) Non-tidal drainage and irrigation ditches excavated in dry land;
>
> (2) Artificially irrigated areas that would revert to dry land if irrigation ceased;
>
> (3) Artificial lakes or ponds created in dry land to collect and retain water, and that are used exclusively for stock watering, irrigation, settling basins, or rice growing;
>
> (4) Artificial reflecting or swimming pools or other small ornamental bodies of water creating in dry land for aesthetic reasons;
>
> (5) Water filled depressions created in dry land incidental to construction activity and pits excavated in dry land for the purpose of obtaining fill, sand, or gravel unless and until the construction or excavation operation is abandoned and the resulting body of water meets the definition of waters of the United States.

Significant Nexus Test

The 1986/1988 definition of waters of the U.S. has been further refined through decisions of the federal courts, including the Supreme Court's *Rapanos* decision. In 2008, USEPA and the Corps issued guidance regarding how the Agencies apply Justice Kennedy's significant nexus test as articulated in *Rapanos*. This guidance applies only to the 1986/1988 definition of waters of the U.S. However, the Agencies incorporated aspects of the significant nexus test into the text of the 2015 Clean Water Rule. The Agencies entirely omitted the test from the 2020 Navigable Waters Protection Rule.

Generally, the significant nexus standard is interpreted and used to conduct delineations under the 1986/1988 waters of the U.S. definition as follows:

1. The Corps and USEPA generally apply the significant nexus analysis to determine the jurisdictional status of the following water features:
    a. Non-navigable tributaries that are not relatively permanent;
    b. Wetlands adjacent to non-navigable tributaries that are not relatively permanent;
    c. Wetlands adjacent to, but not directly abutting a relatively permanent non-navigable tributary.
2. A significant nexus analysis assesses the flow characteristics and functions of the tributary itself and the functions performed by all wetlands adjacent to the tributary to determine if they significantly affect the chemical, physical, and biological integrity of downstream traditional navigable waters;
3. Significant nexus includes consideration of hydrologic and ecologic factors including:
    a. Volume, duration, and frequency of flow, including consideration of certain physical characteristics of the tributary,

b. Proximity to the traditional navigable water,

c. Size of the watershed,

d. Average annual rainfall,

e. Average annual winter snow pack,

f. Potential of tributaries to carry pollutants and flood waters to traditional navigable waters,

g. Provision of aquatic habitat that supports a traditional navigable water,

h. Potential of wetlands to trap and filter pollutants or store flood waters, and

i. Maintenance of water quality in traditional navigable waters.

2020 Navigable Waters Protection Rule

On April 21, 2020, the Agencies published in the Federal Register a revised definition of waters of the U.S., which is currently scheduled to become effective on June 22, 2020. However, twenty-two environmental groups filed two complaints in differing federal district courts challenging the 2020 Navigable Waters Protection Rule, while seventeen states and several municipalities brought suit in the Northern District of California ("State litigation"). On May 18, 2020, in the State litigation, the State of California filed a motion for preliminary injunction seeking to stay implementation of the 2020 Navigable Waters Protection Rule. Consequently, it is unclear whether the rule will become effective as scheduled.

The 2020 Navigable Waters Protection Rule seeks to provide more streamlined categories of those water features considered waters of the U.S., and those features exempt from CWA jurisdiction, though the rule's definitions and preamble add nuance to application of those categories. Notably, the rule eliminates the significant nexus analysis established by Justice Kennedy's concurring opinion in *Rapanos*. Below we provide the categories of waters that are considered jurisdictional and not jurisdictional under the 2020 Navigable Waters Protection Rule.

Pursuant to the 2020 Navigable Waters Protection Rule, the following four (4) features are considered jurisdictional-by-rule:

1. Traditional navigable waters, including the territorial seas.

2. Tributaries that either contribute flow year-round ("perennial") or "continuously during certain times of the year and more than in direct response to precipitation" ("intermittent"), during those years where precipitation and climactic conditions are approximately average, when taking into account a 30-year rolling period ("typical year").

    a. A tributary would continue to be subject to federal jurisdiction where it contributes surface water flow in a typical year to a downstream jurisdictional water through: (i) a channelized non-jurisdictional surface water feature, (ii) a subterranean river, (iii) a culvert, (iv) dam, (v) tunnel or similar artificial feature, or (vi) a debris pile, boulder field, or similar natural feature.

b. The term tributary includes ditches that either relocate a tributary, are constructed in a tributary, or are constructed in an adjacent wetland, where the ditch satisfies the flow conditions described above.

c. Managed tributary systems, or tributaries that have been altered or relocated are considered jurisdictional as long as they satisfy the definition of "tributary," including flow conditions.

3. Certain lakes, ponds, and impoundments of jurisdictional waters. To be considered jurisdictional, the lake, pond or impoundment must either be navigable-in-fact, or contribute flow in a typical year to a water feature that is considered jurisdictional-by-rule through channelized flow.

4. Wetlands adjacent to other jurisdictional waters. To be considered jurisdictional under the 2020 Navigable Waters Protection Rule, the wetlands:

   a. must "abut," meaning "to touch at least at one point or side of," an otherwise jurisdictional water; or

   b. must have a direct hydrologic surface connection to other jurisdictional non-wetland waters in a typical year; or

   c. may be separated from jurisdictional waters only by a natural berm, bank, dune, or other similar natural feature would also be subject to federal jurisdictional; and

   d. are not adjacent to other wetlands.

The following twelve (12) categories of waters will not be considered jurisdictional under the 2020 Navigable Waters Protection Rule:

(1) groundwater;

(2) ephemeral water features that flow only in direct response to precipitation;

(3) diffuse stormwater runoff and directional sheet flow over upland;

(4) ditches that are not traditional navigable waters, tributaries, or that are not constructed in adjacent wetlands, subject to certain limitations;

(5) prior converted cropland;

(6) artificially irrigated areas that would revert to upland if irrigation ceased;

(7) artificial lakes and ponds that are not jurisdictional impoundments and that are constructed or excavated in upland or non-jurisdictional waters;

(8) water-filled depressions excavated or constructed in upland or in non-jurisdictional waters incidental to mining or construction activity, and pits excavated in upland or in non-jurisdictional waters for the purpose of obtaining fill, sand, or gravel;

(9) stormwater control features constructed or excavated in upland or in non-jurisdictional waters;

(10) groundwater recharge, water reuse, and wastewater recycling structures constructed or excavated in upland or in non-jurisdictional waters;

(11) waste treatment systems; and

(12) water features that are not identified as jurisdictional by rule.

3.3 Literature Review

ESA reviewed the following information relevant to this delineation:

- Jepson eFlora (Jepson Flora Project, 2012);
- 2012 GIS retrieved aerial photographs;
- USDA NRCS, Web Soil Survey online application;
- *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (Version 2.0) (Corps, 2008);
- *National List of Wetland Plants* and *California 2012 Final State Wetland Plant List* (Lichvar and Kartesz, 2012); and
- Standard biological references and field guides.

3.4 Field Survey Methods

3.4.1 Dates

ESA biologists M. Giolli and M. Lowe conducted a routine delineation of waters of the U.S. within the delineation study area on November 7 and December 3, 2012. ESA biologists M. Giolli and R. Haines confirmed that conditions from 2012 within the delineation study area remained accurate on October 4, 2018. ESA biologists Joe Sanders and Nicole Ibanez further investigated the study area on July 8, 2020 and mapped one additional aquatic feature.

3.4.2 Field Delineation Methods

Data Collection

The delineation used the "Routine Determination Method" as described in the *1987 Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory, 1987), hereafter called the "1987 Manual." The 1987 Manual was used in conjunction with the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (Version 2.0) (Arid West Supplement)

(Corps, 2008), hereafter called the "Arid West Supplement." For areas where the 1987 Manual and the Arid West Supplement differ, the Supplement was followed.

All wetland and drainage signatures on the aerials were investigated within the delineation study area. The biologists walked the delineation study area in such a manner as to ensure that visual coverage was 100 percent. All aquatic resources within the study area were delineated by comparing the aerial image to the existing site condition and GPS data collection.

Data were collected at 11 sample points within the study area. In accordance with the Corps' San Francisco District guidance (2007), sample points were taken at sites representative of the vegetation, hydrology, and physical characteristics across the various wetland types and at adjacent upland areas. Results were extrapolated to nearby wetlands exhibiting similar vegetation and hydrologic conditions. Paired upland data points were established for each wetland data point where feasible. Arid West Region data sheets were used to record information at each data point.

Three sample points established in 2012 (wetland SP1, upland SP2, and upland SP7) were revisited in 2018 for data collection to confirm 2012 delineation boundaries remained accurate. The corresponding Arid West Region data sheets from 2012 were used to record updated information at each of the three sample points. In addition, eight new sample points (SP 12 – SP 19) were collected in 2020, which yielded one new aquatic feature being mapped.

Determination of Hydrophytic Vegetation

At each sample point, vegetation was analyzed within a 5-foot radius for herbaceous species, 10-foot radius for shrub species, and 30-foot radius for trees. Shrubs and trees were only recorded if they appeared to be rooted within the potential wetland area. All species noted within the study plots were recorded on the data sheets. The indicator status of each species was confirmed in the field, to the extent feasible, with the *California 2012 Final State Wetland Plant List* (Lichvar and Kartesz, 2012) and dominance and/or prevalence calculations were generally performed in the field as well. In accordance with Corps guidance, plant species not listed were considered upland (UPL) for the purposes of this delineation. When the vegetation passed either the dominance or prevalence test, the point was considered to have hydrophytic vegetation.

Determination of Hydric Soils

Soils were analyzed in accordance with the Corps' *Arid West Supplement* (2010). Soil pits were excavated to the maximum depth possible and soil color was matched against a standard color chart (Munsell, 2000). Soils were also inspected for redoximorphic features and soil texture was determined. It was then possible to determine if the soils met any of the hydric soils criteria listed on the Arid West data sheets. Where soils did not exhibit hydric soil criteria consideration was given as to whether the data point in question had the potential to be saturated, ponded, or have a water table within 12 inches of the surface for 14 or more consecutive days during the growing season. With the presence of wetland vegetation and hydrology, this technical standard can be used to characterize a soil as hydric (Corps, 2008).

Determination of Wetland Hydrology

Hydrology was assessed using the Corps' 2010 *Arid West Supplement* hydrology indicators (e.g., oxidized rhizospheres along living roots, aquatic invertebrates, drift deposits and sediment deposits in a riverine system). Soils in all the sample pits encountered were moist to saturated at the time of the delineation field work, in part due to antecedent rainfall. Where hydrology indicators were weak, consideration was given as to whether the technical standard quoted above for hydrology and soils might reasonably be applied to a given site.

3.4.3 Field Mapping

Lake OHWMs, wetland boundaries, and wetland and upland sample points were recorded in the field using a Trimble GeoXT sub-meter accuracy global positioning unit (GPS). Maps of vegetation around Lake Merced, digitized from aerials and field verified (Nomad, 2010 and ESA, 2012; ESA, 2018; ESA, 2020), were used as a basis for this delineation. Field notes were taken on the characteristics of each feature (vegetation type and quality, disturbance levels, etc.).

3.5 Delineation Mapping and Acreage Calculations

Mapping was done using ArcGIS 10.1. Field data was overlaid on digital ortho-rectified aerial photographs covering the study areas and the 2012 vegetation layer and used to map the delineation results. This included correction of original data based on field observations as well as heads up digitizing using field maps and notes.

Section 404 jurisdiction at Impound and South Lakes was determined using elevation data as well as vegetation and hydrology. Willow scrub at Impound and South Lakes within the study area occurs from the water's edge to elevations 20 feet and more above the lake level. It was assumed that some willow scrub would be classified as arroyo willow wetland and the rest as willow riparian scrub, but willow stands are so dense that it was, for the most part, impossible to take sample points within them. Similarly, swamp knotweed occurs in conditions ranging from permanently inundated wetland terraces fringing the lakes to the upper lake banks, where it is co-dominant with California blackberry and there are no indicators of wetland soils or hydrology. Therefore, field investigations focused on determining an elevation marking the upper limits of wetlands. Post-field comparison of the elevations of wetland versus upland sample points, as well as additional GPS reference points, suggests that the upper limit of wetlands at South and Impound Lakes can reasonably and conservatively be drawn at approximately 8 feet City Datum;[2] this line was used to delineate arroyo willow wetlands and to separate some areas mapped as dominated by swamp knotweed into wetland and upland polygons. These conditions delineated in 2012 were confirmed accurate in 2018. One additional willow-dominated area was mapped above 8 feet in elevation in 2020, which is discussed in the results section.

[2] Elevations at 1-foot contours were derived from Lidar data for the project area. When a point fell between contours it was assigned the elevation mid-point between the two contours. Allowing for errors in elevation and GPS data, most upland points were at elevations above 8.5 feet and most wetland points were at elevations below 8 feet. The average upland point was at 9.4 feet, the average wetland point was at 7.2 feet, and the average of all points was 8.1 feet.

Section 10 jurisdiction at Lake Merced was mapped based on the maximum extent of navigable water, which was determined by the presence of open water and physical evidence of an OHWM, such as a line on the shore, shelving, changes in soil, or the absence of terrestrial vegetation. Therefore, in the case of Lake Merced, the limits of Section 10 jurisdiction correspond to the limits of Section 404 'other waters.'

The extent of RHA Section 10 and CWA Section 404 jurisdiction for tidal waters (the Pacific Ocean) at Fort Funston correspond to MHW and the HTL, respectively.

MHW was selected consistent with the following definition of navigable waters from the Corps:

> "navigable waters of the United States are those waters subject to the ebb and flow of the tide shoreward to the mean high water mark and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or destroy navigable capacity."

The HTL was selected consistent with the following definition from the Corps[3]:

> "The term 'high tide line' means the line of intersection of the land with the water's surface at the maximum height reached by a rising tide. The high tide line may be determined, in the absence of actual data, by a line of oil or scum along shore objects, a more or less continuous deposit of fine shell or debris on the foreshore or berm, other physical markings or characteristics, vegetation lines, tidal gages, or other suitable means that delineate the general height reached by a rising tide. The line encompasses spring high tides and other high tides that occur with periodic frequency but does not include storm surges in which there is a departure from the normal or predicted reach of the tide due to the piling up of water against a coast by strong winds such as those accompanying a hurricane or other intense storm."

Both the MHW and HTL were based on inspecting tidal data information published by NOAA, and comparing to field observations of tidal conditions at the project area. Based on tidal information, a HTL elevation of 7.4 feet NAVD was selected for the Project, by adjusting the highest astronomical tide (HAT) of 7.3 feet NAVD at the San Francisco tide gage (NOS Sta. 9414290; **Table 2**) by 0.1 feet, consistent with the high tide height offset used by NOAA to convert high tide elevations to the subsidiary "Ocean Beach, outer coast" tide station (NOS Sta. 9414275).

The limits of these jurisdictional areas were verified in the field by observations of physical evidence such as the wrack line.

Stream length and area calculations for other waters of the U.S. and wetlands were computed using ArcGIS 10.1.

3 Definition of high tide line from 33 CFR Part 328, Definition of Waters of the United States, U.S. Army Corps of Engineers: http://www.nap.usace.army.mil/Portals/39/docs/regulatory/regs/33cfr328.pdf

TABLE 2
TIDAL DATUMS FOR SAN FRANCISCO (NOS STA. 9414290)

Datum	Elevation (feet NAVD)	Description
SFCD	11.326	San Francisco City Datum
HAT	7.3[1]	High Astronomical Tide
MHHW	5.9	Mean Higher High Water
MHW	5.3	Mean High Water
MTL	3.2	Mean Tide Level
MSL	3.2	Mean Sea Level
MLW	1.2	Mean Low Water
MLLW	0.06	Mean Lower Low Water

[1] HAT of 7.4 feet NAVD selected for ‘Ocean Beach, open coast’ Sta. 9414275 based on adding 0.1 feet.

SOURCE: NOAA

CHAPTER 4
Results

4.1 Organization

Delineation results for the Project delineation study area are presented below. Delineation maps and datasheets for the Project and other supporting information, including a jurisdictional determination analysis map, a soils map, and representative photographs of the delineation study area, are presented in Appendices A through F. Appendix C includes AJD documentation issued by the Corps, confirming the non-jurisdictional status of the Vista Grande Canal.

4.2 Results Summary

A total of 18.830 acres (820,254 square feet) of potentially jurisdictional waters of the U.S. occur within the delineation study area. **Table 3** below presents all potentially jurisdictional delineated features within the delineation study area and summarizes estimated Corps Section 404 and Section 10 jurisdictional areas for each feature type, as applicable. All areas presented in this delineation as potentially federally jurisdictional are preliminary in nature, and are subject to revision, pending review and verification by the Corps.

The Westlake Park area and most of the Fort Funston area (with the exception of Other Waters and non-jurisdictional features discussed below) did not include wetlands or other waters under Section 404, nor Section 10 jurisdiction, and are not discussed further.

Two features - the Vista Grande Canal and the vegetated swales at Fort Funston - were determined to be non-jurisdictional based on the currently applicable definition of waters of the U.S. and accompanying guidance (1986/1988 Rule), the 2015 Clean Water Rule, and the 2020 Navigable Waters Protection Rule, as detailed in Section 4.3.3 below.

4.3 Waters of the U.S.

The Project delineation study area includes wetlands and other waters under Section 404 as well as Section 10 jurisdiction. Of the 18.830 acres of features subject to Section 404 jurisdiction, a subset of those, totaling approximately 12.713 acres, are subject to Section 10 jurisdiction.

TABLE 3
AQUATIC RESOURCES WITHIN THE DELINEATION STUDY AREA

Resource Type/Name	Area (ac)	Area (sq ft)	Sample points
Wetlands			
Bulrush Wetland			
BW-1	3.178	138,434	SP 1, SP 9
BW-2	0.030	1,307	--
BW-3a	0.168	7,318	--
BW-3b	0.002	87	SP 3
BW-4ab	0.281	12,240	--
BW-5	0.018	784	--
BW-6	0.064	2,788	SP 6
BW-7	0.064	2,788	--
BW-8	0.003	131	--
BW-9	0.122	5,314	--
Subtotal	*3.930*	*171,191*	--
Knotweed Wetland			SP 10
KW-1	0.188	8,189	--
KW-2	0.051	2,222	--
KW-3	0.017	741	--
KW-4	0.040	1,742	--
KW-5	0.021	915	--
KW-6	0.017	741	--
KW-7	0.009	392	--
KW-8	0.030	1,307	--
KW-9	0.088	3,833	--
KW-10	0.158	6,882	--
KW-11	0.092	4,008	--
Subtotal	*0.711*	*30,971*	--
Arroyo Willow Wetland			
AWW-1a	0.004	174	--
AWW-1b	0.311	14,438	SP 12
AWW-2	0.842	36,678	SP 10
AWW-3	0.032	1,394	--
AWW-4	0.090	3,920	--
AWW-5	0.029	1,263	--
AWW-6a	0.102	4,443	--
AWW-6b	0.009	392	--
AWW-6c	0.010	436	--
AWW-6d	0.027	1,176	--
Subtotal	*1.476*	*64,314*	--
Total Wetlands	***6.117***	***266,476***	--
Other Waters			
OW-1 Lake Merced South Lake	4.695[a]	204,514	--
OW-2 Lake Merced Impound Lake	4.994[b]	217,539	--
OW-3 Pacific Ocean	3.024[ac]	131,725	--
Total Other Waters	***12.713***	***553,778***	--
Total Section 404 Waters	**18.830**	**820,254**	

* Potentially jurisdictional wetlands are directly abutting Lake Merced, and therefore, the jurisdictional analysis would have the same result under all three potentially applicable CWA rules.

a Area of Section 404 'other waters' jurisdiction in Lake Merced South Lake (OW-1), which is 4.695 acres, is the same as the limits of Section 10 jurisdiction for OW-1

b Area of Section 404 'other waters' jurisdiction in Lake Merced Impound Lake (OW-2), which is 4.994 acres, is the same as the limits of Section 10 jurisdiction for OW-2

c Area of Section 404 'other waters' jurisdiction of the Pacific Ocean (OW-3), which is 3.024 acres and based upon the HTL, includes a subset of Section 10 jurisdiction, which is 2.683 acres (116,871 square feet) as based upon the MHW line.

SOURCE: ESA, 2020

4.3.1 Wetlands

Emergent Wetlands

Emergent wetlands in the Project delineation study area occur within and adjacent to the OHWM of South and Impound Lakes in areas that are permanently or nearly permanently inundated or saturated. Sample points 1, 3, 6, 9, and 10 represent emergent wetland conditions (see Appendix B for datasheets) and were located at or near the water's edge within or adjacent to the lake OHWM.

Vegetation

Emergent wetlands in the study area are dominated by the obligate hydrophytes bulrush and swamp knotweed. Associated species include water parsley (OBL), Baltic rush (FACW), willow herb (*Epilobium ciliatum*; FACW), dotted smartweed (*Persicaria punctata*; OBL), and American speedwell (*Veronica americana*; OBL).

Soils

Soils in the upper layers (0 to 5 inches) varied between the wetland sample points and ranged from a matrix of 2.5Y 3/2 and 2.5Y 3/2 at sample points 1 and 3 to 10YR 2/1 at sample point 6 to 10YR 2/2 at sample points 9 and 10. Soils at greater depths ranged from 10Y 2.5/1 at sample point 1to 10YR 3/3 and 2.5Y 3/1 at sample point 6 to 10YR 3/2 at sample points 9 and 10. Soils corresponded with hydric soil indicator A4: Hydrogen sulfide at sample points 1 and 9, which were the lowest points in elevation relative to the lake level. Hydric soil indicator S5: Sandy redox was evident at sample points 3, 6, and 10, which all had a layer at least 4 inches thick exhibiting redoximorphic features within the upper 6 inches of soil.

Hydrology

Indicators of hydrology at sample points 1, 3, 6, 9, and 10 included A1: observation of surface water, A3: saturation at the soil surface or within the upper 12 inches, A4: a water table no deeper than 12 inches depth, and C1: hydrogen sulfide odor at sample points 1 and 9.

Arroyo Willow Wetlands

Arroyo willow wetlands occur in the study area on the banks of South and Impound Lakes. Most of the Arroyo willow wetlands occur below 8 feet, except for one Arroyo willow wetland (wetland AWW-1b) which occurs above 8 feet (see below for additional discussion). Given that these wetlands are directly abutting South and Impound Lakes, the jurisdictional analysis for the willow wetlands would be the same under all three potentially applicable definitions of waters of the U.S. Sample points 10 and 12 represent arroyo willow wetland conditions (see Appendix B for datasheets) as well as knotweed wetland conditions.

Arroyo Willow Wetlands Below 8 Feet in Elevation

Vegetation

Arroyo willow wetlands in the study area are dominated exclusively by arroyo willow (FACW) in the shrub layer. Based on the field delineation results and using the methods described in Section 3.5, ESA determined that willow scrub above 8 feet City Datum elevation could be characterized as willow riparian scrub, while willow below 8 feet elevation was more appropriately described as arroyo willow wetland, with the exception of one other willow-dominated feature above 8 feet elevation which is discussed below. Associated species in the willow wetland understory include California bulrush (OBL) and swamp knotweed (OBL).

Soils

Soils at data point 10 were identical to those of the paired upland point (sample point 11) in matrix color: 10YR 2/2 (0-3 inches), 10YR 3/2 (3-6 inches, and 10YR 3/2 (6 plus inches). However, soils at sample point 10 had the requisite redox (10 percent bright mottles with a color of 10YR 4/6) in the upper 6 inches and a layer of sandy loam from 0 to 3 inches, while soils at sample point 11 only exhibited redox concentrations below 6 inches and had an organic layer from 0 to 3 inches.

Hydrology

Hydrologic indicators recorded at data point 10 consisted of primary indicators A2: High water table and A3: Saturation. The water table was present at 7 inches depth and soils were saturated to 1 inch depth.

Arroyo Willow Wetland Above 8 Feet in Elevation

There is one aquatic feature that occurs above 8 feet in elevation along the banks of Lake Merced This feature (AWW-1b) was mapped during the survey conducted in July of 2020. The majority of the Lake Merced banks within the study area consist of sandy soils which drain quickly. The water surface elevation of Lake Merced fluctuates within and between years. When these areas are inundated by a raised water surface elevation of the lake during rain events, they likely drain quickly as the water level recedes through a combination of evaporation, transpiration, groundwater infiltration, and manmade extractions. So even though a given sandy bank may be inundated annually, the soils drain quickly enough as the water level recedes for upland conditions to persist (captured in sample points SP2, SP4, SP5, SP7, SP8, SP11, SP13, and SP19). However, if the soil does not drain quickly then is it possible for wetland conditions to form at higher elevations than those with a predominately sandy substrate. One such area (wetland AWW-1b) surrounds the Lake Merced overflow structure, the only physical outlet of Lake Merced. The soil surrounding the immediate area contains a clay layer situated under approximately five inches of sand (captured in sample point SP 12). This clay substrate does not drain quickly, and so when the water surface elevation of the lake rises near or to the elevation of the overflow structure, soil saturation is able to persist long enough for wetland conditions to occur in this localized area even though neighboring sandy areas drain quickly enough for upland conditions to persist.

4.3.2 Other Waters

Pacific Ocean

The waters of the Pacific Ocean are navigable-in-fact and are used for international and intrastate commerce; therefore, the Pacific Ocean is a TNW for the purposes of Section 404 jurisdiction. TNW are considered waters of the U.S. under all three potentially applicable definitions of waters of the U.S. Section 404 jurisdiction was mapped within the delineation study area to the HAT, as described in Section 3.5. This is the beach below Fort Funston, subject to the ebb and flow of the tide and characterized by unconsolidated sands and no vegetation, and these other waters extend to an elevation of approximately 7.4 feet (NAVD88) on the beach.

The waters of the Pacific Ocean are also regulated under Section 10 of the RHA as navigable waters up to the MHW line. This area is mapped to an elevation of approximately 5.3 feet (NAVD88) on the beach at Fort Funston.

Lake Merced

As described in the setting discussion above, Lake Merced is the largest natural freshwater lake in the San Francisco and currently comprises four lakes: North, East, South, and Impound Lakes. Lake Merced is navigable in fact because it provides recreational uses for local residents and visitors and its waters are thus regulated by the Corps under Section 404 of the CWA up to the extent of open water at the time of the delineation field work and under Section 10 of the RHA up to the OHWM, which was determined as described in Section 3.5. Lakes that are navigable in fact are considered waters of the U.S. under all three potentially applicable definitions of waters of the U.S.

4.3.3 Non-jurisdictional Aquatic Features

Vista Grande Canal

Before development of Daly City, natural drainages conveyed surface water runoff and stormwater to Lake Merced. These natural drainages were later replaced by an underground storm sewer system. The Vista Grande Canal is a trapezoidal, man-made channel within the study area originally constructed over a century ago to capture and redirect stormwater and agricultural waters from Lake Merced. Historical maps show that the Canal was excavated in dry land and did not follow any natural drainage course or otherwise intersect wetlands, natural tributaries, or drainages. The channel bed and banks consist of bricks and cement. At the time of the field delineations in 2012 and 2018, the Canal consisted of open water with occasional unvegetated sediment deposits of silt and sand-sized grains. Mosses and trapped sediment provide a substrate on the banks for annual grasses and other opportunistic herbaceous species. The upper banks above the lined channel support annual grasses, non-native trees, horticultural shrubs, and native California blackberry thickets. Few species occurring are native riparian species and none are actually supported by water conveyed in the canal. Most trees and shrubs are on the golf course side of the canal. At the time of the field delineation, open water ranged from approximately 4 to 9 feet in width and was no more than 2 to 4 inches in depth. The OHWM, as evidenced by a line below which there was no vegetation, was approximately 8 inches above the channel bed and varied from 5 feet in width in narrow sections of the canal to 11.5 feet in width in wider sections of the canal. Although a few wetland species, such as cattail (*Typha latifolia*), bulrush, willow herb, and rabbitsfoot grass (*Polypogon monspeliensis*) can colonize the sediment deposits in the canal, field observations that occurred after rain events indicate the sediment and wetland vegetation are likely to be scoured out each year by high flows in the canal. Therefore, no jurisdictional wetlands (as opposed to "other waters") occur within the Canal.

On April 29, 2016, following Daly City's submittal of information about the history, construction, and location of the Canal, the Corps issued a jurisdictional determination that it does not consider the Vista Grande Canal within the project site to meet the definition of a water of the U.S. pursuant to the 1986/1988 definition of waters of the U.S. and accompanying guidance. A review of historical imagery indicated the Vista Grande Canal, a non-tidal feature, was excavated in dry land and did not follow any natural drainage feature or intersect a natural tributary. Further, the age of the channel, the brick and concrete lined invert, and low physical and biological functions all contributed to the Corps decision not to assert jurisdiction over the Canal as a water of the U.S. (Corps, 2016). This AJD letter is included in Appendix C. Given the status of the 2020 Navigable Waters Protection Rule, the following Table (**Table 4**) is provided, which discusses the status of the Canal under all three potentially applicable rules.

TABLE 4
VISTA GRANDE CANAL STATUS UNDER VARIOUS JURISDICTIONAL RULES

Rule	Status of the Vista Grande Canal	Rationale	Citation
1986/1988 definition of waters of the U.S.	Not jurisdictional	USEPA and the Corps do not generally consider non-tidal drainage ditches excavated in dry land to be waters of the U.S., but considers their jurisdictional status on a case-by-case basis. On April 29, 2016, the Corps issued an AJD providing the required case specific analysis, and determining that the Canal was not jurisdictional.	• 51 Fed.Reg. 41206, 41217 (1986). • Appendix C
2015 definition of waters of the U.S.	Not jurisdictional	In pertinent part, the 2015 Clean Water Rule indicates that the following features are not considered jurisdictional: • Stormwater control features constructed to convey, treat, or store stormwater, which are created in dry land. • Ditches with intermittent flow that are not a relocated tributary, excavated in a tributary, or drain wetlands.	80 Fed.Reg. 37054, 37118 (2015).
2020 definition of waters of the U.S.	Not jurisdictional	In pertinent part, the 2020 Navigable Waters Protection Rule indicates that the following features are not considered jurisdictional: • Stormwater control features constructed or excavated in upland or in non-jurisdictional waters. • Ditches that are not traditional navigable waters, tributaries, or that are not constructed in adjacent wetlands.	85 Fed.Reg. 22250, 22338 (2020).

Fort Funston Vegetated Swales

Vegetated swales were investigated at Fort Funston. The main swale runs from west to east for approximately 621 linear feet and discharges into a culvert that presumably empties into a sewer system. Two side swales flow from a parking lot to the main swale and it is presumed that this feature was constructed in dry land (sand dunes) to convey parking lot runoff offsite. The swales are vegetated primarily by iceplant and also support a few annual grasses. There was no indication that the swales support seasonal hydrophytic vegetation. These swales does not exhibit a bed, bank, or ordinary high water mark, and do not contribute substantial flow to a TNW. As such, they are isolated non-wetland swales or erosional features and are excluded by rule and not considered waters of the U.S. under the 2015 Clean Water Rule and the 2020 Navigable Waters Protection Rule. Given that the swales are isolated, intrastate, non-wetland water features, they do not have a significant effect (more than speculative or insubstantial) on the chemical, physical, and biological integrity of a TNW. Therefore, they are similarly not considered waters of the U.S. under the 1986/1988 definition of waters of the U.S.

4.4 Clean Water Act Analysis

This section provides a brief summary of how project aquatic features qualify as Clean Water Act jurisdictional features under the three potentially applicable definitions of waters of the U.S. A Jurisdictional Determination Analysis Map, which summarizes the information presented here, can be found in Appendix C. This section provides a brief summary of the Section III Clean Water Act Analysis (CWA Analysis), Parts A and B for all delineated features, which is supplemental information requested by the Corps' San Francisco District. Information used to support the CWA Analysis presented herein includes the following: Review of U.S. Geological Survey (USGS) topographic quadrangles and high resolution aerials covering the study area and field studies conducted in November and December 2012.

The Pacific Ocean is a TNW and regulated under Section 404 to the HAT and Section 10 to MHW. Lake Merced is navigable in fact and supports a recreational fishery and is therefore also regulated as a TNW. These features are jurisdictional by rule under all three potentially applicable definitions of waters of the U.S. Wetlands within and adjacent to Lake Merced are regulated by virtue of their adjacency and direct hydrologic connection to a TNW. These features are jurisdictional by rule under all three potentially applicable definitions of waters of the U.S.

The Vista Grande Canal is a man-made channel that was excavated in dry land, and does not follow any natural drainage course or otherwise intersect natural tributaries, wetlands, or drainages. The Canal is therefore considered not jurisdictional by rule pursuant to the 2015 Clean Water Rule, and the 2020 Navigable Waters Protection Rule. The 1986/1988 definition of waters of the U.S. and accompanying guidance indicates that USEPA and the Corps do not generally consider non-tidal drainage ditches excavated in dry land to be waters of the U.S., but consider their jurisdictional status on a case-by-case basis. The Corps issued an Approved Jurisdictional Determination (AJD; File Number 2014-00030S) on April 29, 2016 that provides the required case-specific analysis of the Vista Grande Canal, and confirms the Vista Grande Canal will not be regulated as a water of the U.S. under the 1986/1988 definition of waters of the U.S. (Corps, 2016).

The vegetated swales at Fort Funston do not exhibit a bed, bank, or ordinary high water mark, and do not contribute substantial flow to a TNW. Therefore, they are isolated non-wetland swales or erosional features and are excluded by rule and not considered waters of the U.S. under the 2015 Clean Water Rule and the 2020 Navigable Waters Protection Rule. Given that the swales are isolated, intrastate, non-wetland water features, they do not have a significant effect (more than speculative or insubstantial) on the chemical, physical, and biological integrity of a TNW. Therefore, they are similarly not considered waters of the U.S. under the 1986/1988 definition of waters of the U.S.

CHAPTER 5

Report Preparation and References

5.1 Report Preparation

ESA
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San Francisco, CA 94108
(415) 896-5900

Project Managers:	A. Moore and A. Thompson
Delineation:	M. Lowe and M. Giolli (2012); M. Giolli and R. Haines (2018); Joe Sanders (2020) and Nicole Ibanez (2020)
Report Preparation:	M. Lowe and M. Giolli (2012); R. Haines (2018); Josh Boldt (2020); Joe Sanders (2020)
GIS:	M. Lowe and M. Giolli
Graphics:	R. Teitel, M. Lowe, M. Giolli

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APPENDIX A
Delineation Maps

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Path: U:\GIS\GIS\Projects\207xxx\207036.01_Vista_Grande_Drainage_Basin\Bio\Wetland Delineation Revised April 2019\A1_Delin_map_overview_2018.mxd, JSANDERS 5/8/2019

SOURCE: ESA, 2014, 2018, 2020

Vista Grande Drainage Basin Improvement Project.207036.01

Figure A-1
Delineation Overview

ESA

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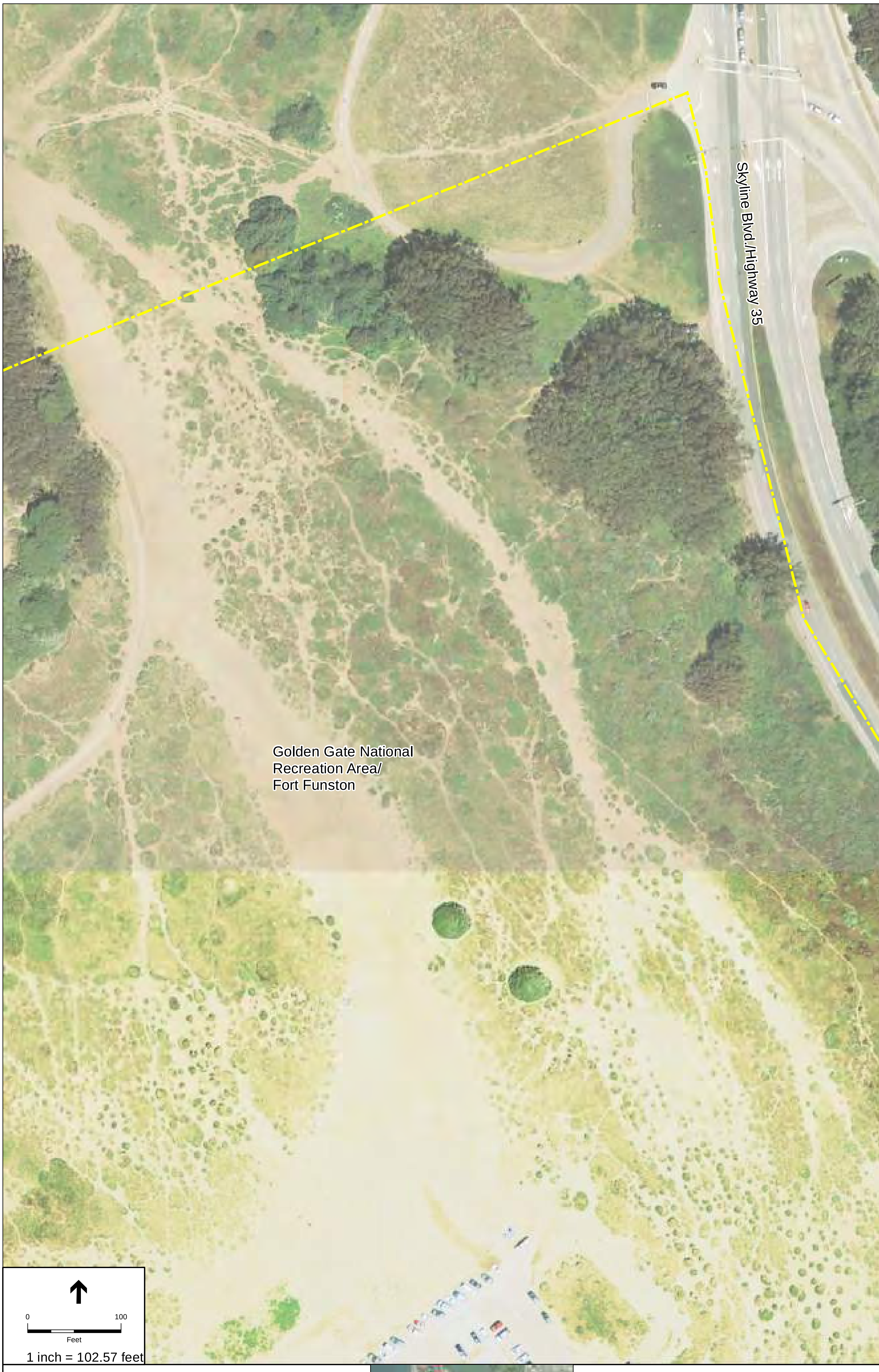
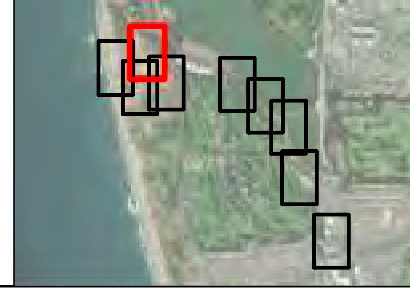
Golden Gate National
Recreation Area/
Fort Funston
Pacific Ocean
MHW = 5.4 ft
(NAVD 88)
HTL (HAT) = 7.4 ft
(NAVD 88)
San Francisco ocean outlet
TNW:
Pacific Ocean
Section 10
2.683 acre
Daly City ocean outlet
OW-3
Pacific Ocean
Section 404
3.024 acre
0
100
Feet
1 inch = 102.57 feet
Sample Points
Non-wetland
Vegetated Swale
Delineation Study Area
Section 10 Waters-12.372 ac
Vista Grande Canal-
non-jurisdictional
Section 404 Waters
Other Waters-12.713 ac
Wetland-6.117 ac
Appendix A
Vista Grande Drainage Basin Improvement Project
Aquatic Resources Delineation: Map 1 of 9
For contiguous features see adjacent maps for feature information
Map scale: 1:1200
Source: ESA, 2012, 2018, 2020; USGS, 2011
Prepared by M. Lowe, ESA, June 2013; Revised August 2014,
December 2018, May 2019, and July 2020



Sample Points
Non-wetland Vegetated Swale
Delineation Study Area
Section 10 Waters-12.372 ac
Vista Grande Canal-non-jurisdictional
Section 404 Waters
Other Waters-12.713 ac
Wetland-6.117 ac

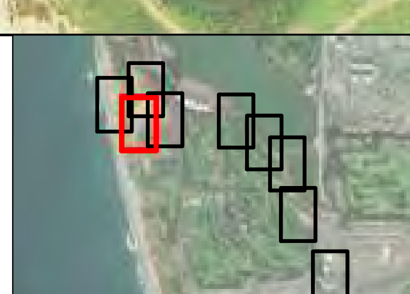


Appendix A
Vista Grande Drainage Basin Improvement Project
Aquatic Resources Delineation: Map 2 of 9
For contiguous features see adjacent maps for feature information
Map scale: 1:1200
Source: ESA, 2012, 2018, 2020; USGS, 2011
Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020

- Sample Points
- Non-wetland Vegetated Swale
- Delineation Study Area
- Section 10 Waters-12.372 ac
- Vista Grande Canal-non-jurisdictional

Section 404 Waters

- Other Waters-12.713 ac
- Wetland-6.117 ac



Appendix A

Vista Grande Drainage Basin Improvement Project

Aquatic Resources Delineation: Map 3 of 9

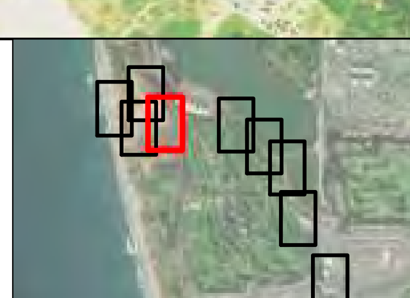
For contiguous features see adjacent maps for feature information

Map scale: 1:1200

Source: ESA, 2012, 2018, 2020; USGS, 2011

Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020

Sample Points
Non-wetland Vegetated Swale
Delineation Study Area
Section 10 Waters-12.372 ac
Vista Grande Canal-non-jurisdictional
Section 404 Waters
Other Waters-12.713 ac
Wetland-6.117 ac



Appendix A
Vista Grande Drainage Basin Improvement Project
Aquatic Resources Delineation: Map 4 of 9
For contiguous features see adjacent maps for feature information
Map scale: 1:1200
Source: ESA, 2012, 2018, 2020; USGS, 2011
Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020

Sample Points
Non-wetland Vegetated Swale
Delineation Study Area
Section 10 Waters-12.372 ac
Vista Grande Canal-non-jurisdictional

Section 404 Waters

Other Waters-12.713 ac
Wetland-6.117 ac

Appendix A

Vista Grande Drainage Basin Improvement Project

Aquatic Resources Delineation: Map 5 of 9

For contiguous features see adjacent maps for feature information

Map scale: 1:1200

Source: ESA, 2012, 2018, 2020; USGS, 2011

Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020

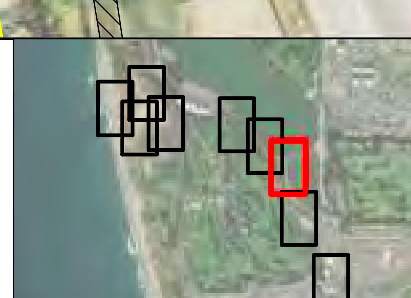
Sample Points
Non-wetland Vegetated Swale
Delineation Study Area
Section 10 Waters-12.372 ac
Vista Grande Canal-non-jurisdictional
Section 404 Waters
Other Waters-12.713 ac
Wetland-6.117 ac

Appendix A
Vista Grande Drainage Basin Improvement Project
Aquatic Resources Delineation: Map 6 of 9
For contiguous features see adjacent maps for feature information
Map scale: 1:1200
Source: ESA, 2012, 2018, 2020; USGS, 2011
Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020

- Sample Points
- Non-wetland Vegetated Swale
- Delineation Study Area
- Section 10 Waters-12.372 ac
- Vista Grande Canal-non-jurisdictional

Section 404 Waters

- Other Waters-12.713 ac
- Wetland-6.117 ac



Appendix A

Vista Grande Drainage Basin Improvement Project

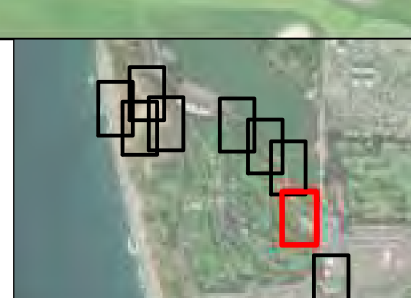
Aquatic Resources Delineation: Map 7 of 9

For contiguous features see adjacent maps for feature information

Map scale: 1:1200

Source: ESA, 2012, 2018, 2020; USGS, 2011

Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020



Appendix A

Vista Grande Drainage Basin Improvement Project

Aquatic Resources Delineation: Map 8 of 9

For contiguous features see adjacent maps for feature information

Map scale: 1:1200

Source: ESA, 2012, 2018, 2020; USGS, 2011

Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020

- Sample Points
- Non-wetland Vegetated Swale
- Delineation Study Area
- Section 10 Waters-12.372 ac
- Vista Grande Canal- non-jurisdictional

Section 404 Waters

- Other Waters-12.713 ac
- Wetland-6.117 ac

Appendix A

Vista Grande Drainage Basin Improvement Project

Aquatic Resources Delineation: Map 9 of 9

For contiguous features see adjacent maps for feature information

Map scale: 1:1200

Source: ESA, 2012, 2018, 2020; USGS, 2011

Prepared by M. Lowe, ESA, June 2013; Revised August 2014, December 2018, May 2019, and July 2020

APPENDIX B

Wetland Datasheets 2012, 2018, and 2020

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Confirmation site visit 10.4.18
M. Giolli, R.Haines

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 11/07/12

Applicant/Owner: City of Daly City State: CA Sampling Point: 01

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): beach Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR): C - Mediterranean California Lat: 37.712604 N Long: 122.489209 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification:

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (X) No ( ) (If no, explain in Remarks.)

Are Vegetation [ ] Soil [ ] or Hydrology [ ] significantly disturbed? Are "Normal Circumstances" present? Yes (X) No ( )

Are Vegetation [ ] Soil [ ] or Hydrology [ ] naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (X)	No ( )
Hydric Soil Present?	Yes (X)	No ( )
Wetland Hydrology Present?	Yes (X)	No ( )

Is the Sampled Area within a Wetland? Yes (X) No ( )

Remarks: Pit is at lake's edge on sandy beach. Sand is moist at surface. Point is below OHWM of lake.
Rain on 10.2.18

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Pinus sp.*	5	Yes	UPL
2.			
3.			
4.			
Total Cover:	5 %		
Sapling/Shrub Stratum			
1. *Salix lasiolepis*	30	Yes	FACW
2. ~~*Rubus ursinus*~~	~~1~~	~~No~~	~~FACU~~
3.			
4.			
5.			
Total Cover:	~~31~~ % 30%		
Herb Stratum			
1. *Schoenoplectus californicus*	25	Yes	OBL
2. ~~*Persicaria punctata*~~	~~5~~	~~No~~	~~OBL~~
3. ~~*Epilobium ciliatum*~~	~~3~~	~~No~~	~~FACW~~
4. ~~*Oenanthe sarmentosa*~~	~~2~~	~~No~~	~~OBL~~
5.			
6.			
7.			
8.			
Total Cover:	~~35~~ % 25%		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum 75 % % Cover of Biotic Crust %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	2	(A)
Total Number of Dominant Species Across All Strata:	3	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	66.7 %	(A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	25 ~~32~~	x 1 =	~~32~~ 25
FACW species	30 ~~33~~	x 2 =	~~66~~ 60
FAC species		x 3 =	0
FACU species	~~1~~	x 4 =	~~4~~
UPL species	5	x 5 =	25
Column Totals:	60 ~~71~~ (A)		~~127~~ (B) 110

Prevalence Index = B/A = ~~1.79~~ 1.83

Hydrophytic Vegetation Indicators:

- [X] Dominance Test is >50%
- [X] Prevalence Index is ≤3.0[1]
- [ ] Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- [ ] Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes (X) No ( )

Remarks:

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Exhibit 5
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SOIL

Sampling Point: 01

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1	2.5Y 3/2	90	10YR 5/8	10	C	M	sand	~~redox is distinct and prominent~~
1+	10Y 2.5/1	100					sand/water mix	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☒ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type:

Depth (inches):

Hydric Soil Present? Yes ◉ No ○

Remarks: Pit dug to 18 ". Pit was inundated at 4.5 inches depth.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☒ High Water Table (A2) *6" below surface*
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☒ ~~Inundation Visible on Aerial Imagery (B7)~~
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches):
Water Table Present?	Yes ◉	No ○	Depth (inches): ~~4.5~~ *6"*
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): ~~2~~ *0"*

Rained 10.2.18

Wetland Hydrology Present? Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:
Aerials show pit location inundated when lake levels are high.

Remarks: Pit location was inundated during December 2012 site visit.
Pit location was not inundated during 10.4.18 site visit.

Confirmation site visit 10.4.18
M. Giolli, R.Haines

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 11/07/12

Applicant/Owner: City of Daly City State: CA Sampling Point: 02

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): convex Slope (%): 5

Subregion (LRR): C - Mediterranean California Lat: 37.712581 N Long: 122.489320 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification:

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes ( )	No (●)
Wetland Hydrology Present?	Yes ( )	No (●)

Is the Sampled Area within a Wetland? Yes ( ) No (●)

Remarks: ~~Pit is about 4 feet above OHWM of lake. Willows are of sufficient size to be rooted well within the water table.~~

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Pinus sp.*	5	Yes	UPL
2.			
3.			
4.			
Total Cover:	5 %		
Sapling/Shrub Stratum			
1. *Salix lasiolepis*	65	Yes	FACW
2. *Rubus ursinus*	10	No	~~FACU~~ FAC
3. Pittosporum sp.	5	No	UPL
4.			
5.			
Total Cover:	~~75 %~~ 80%		
Herb Stratum			
1. ~~*Epilobium ciliatum*~~	~~5~~	~~Yes~~	~~FACW~~
2.			
3.			
4.			
5.			
6.			
7.			
8.			
Total Cover:	~~5 %~~		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum 85 % % Cover of Biotic Crust 0 %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 ~~2~~ (A)

Total Number of Dominant Species Across All Strata: 2 ~~3~~ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% ~~66.7 %~~ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	0
FACW species	65 ~~70~~	x 2 =	~~140~~ 130
FAC species	10	x 3 =	~~0~~ 30
FACU species	0 ~~10~~	x 4 =	~~40~~ 0
UPL species	10 ~~5~~	x 5 =	~~25~~ 50
Column Totals:	85 (A)		~~205~~ (B) 210

Prevalence Index = B/A = ~~2.41~~ 2.47

Hydrophytic Vegetation Indicators:

- ☒ ~~Dominance Test is >50%~~
- ☒ ~~Prevalence Index is ≤3.0[1]~~
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes (●) No ( )

Remarks:

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SOIL

Sampling Point: 02

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
~~0-18~~	~~10YR 3/3~~	~~99~~	~~10YR 6/8~~	~~1~~	~~C~~	~~M~~	~~sand~~	~~redox only in top 2-3 inches~~
0-12	10 YR 3/3	98	10 YR 6/8	2	C	M	sand	redox only in top 2-3"

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ○ **No** ◉

Remarks: Soil is moist but not saturated. Does not meet hydric soil criteria.
Rain on 10.2.18

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches): ______
Water Table Present? Yes ○ No ◉ Depth (inches): ______
Saturation Present? (includes capillary fringe) Yes ○ No ◉ Depth (inches): ______

Wetland Hydrology Present? **Yes** ○ **No** ◉

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No hydrology indicators present.

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 12/03/12

Applicant/Owner: City of Daly City State: CA Sampling Point: 03

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): bank Local relief (concave, convex, none): convex Slope (%): 1

Subregion (LRR): C - Mediterranean California Lat: 37.712393 N Long: 122.488348 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: L1UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes (●)	No ( )
Wetland Hydrology Present?	Yes (●)	No ( )

Is the Sampled Area within a Wetland? Yes (●) No ( )

Remarks: Pit is at water's edge

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Salix lasiolepis*	30	Yes	OBL
2. *Rubus ursinus*	30	Yes	FACU
3.			
4.			
5.			
Total Cover:	60 %		
Herb Stratum			
1. *Juncus balticus ssp. ater*	15	Yes	FACW
2. *Schoenoplectus californicus*	15	Yes	OBL
3. *Veronica americana*	15	Yes	OBL
4. *Persicaria punctata*	10	No	OBL
5. *Erharta erecta*	10	No	UPL
6. *Oenanthe sarmentosa*	5	No	OBL
7. *Anagallis arvensis*	5	No	UPL
8. *Lactuca serriola*	1	No	FACU
Total Cover:	76 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum 5 % % Cover of Biotic Crust %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 80.0 % (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	75	x 1 =	75
FACW species	15	x 2 =	30
FAC species		x 3 =	0
FACU species	31	x 4 =	124
UPL species	15	x 5 =	75
Column Totals:	136 (A)		304 (B)

Prevalence Index = B/A = 2.24

Hydrophytic Vegetation Indicators:

- ☒ Dominance Test is >50%
- ☒ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes (●) No ( )

Remarks:

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SOIL

Sampling Point: 03

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-5	2.5Y 3/1	70	5YR 3/6	30	C	M	sandy	
5-18	2.5Y 3/1	100						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☒ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type:

Depth (inches):

Hydric Soil Present? **Yes** ◉ **No** ○

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☒ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☒ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches):

Water Table Present? Yes ◉ No ○ Depth (inches): 9

Saturation Present? (includes capillary fringe) Yes ◉ No ○ Depth (inches): 4

Wetland Hydrology Present? Yes ◉ **No** ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements   City/County: Daly City, San Francisco Co.   Sampling Date: 12/03/12

Applicant/Owner: City of Daly City   State: CA   Sampling Point: 04

Investigator(s): M. Giolli, M. Lowe   Section, Township, Range: NA

Landform (hillslope, terrace, etc.): terrace   Local relief (concave, convex, none): none   Slope (%): 3

Subregion (LRR): C - Mediterranean California   Lat: 37.712412 N   Long: 122.488344 W   Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes   NWI classification: L1UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed?   Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic?   (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	( )	(●)
Hydric Soil Present?	( )	(●)
Wetland Hydrology Present?	(●)	( )

Is the Sampled Area within a Wetland? **Yes** ( ) **No** (●)

Remarks: Pit is located above OHWM of lake

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Salix lasiolepis*	45	Yes	FACW
2. *Rubus ursinus*	45	Yes	FACU
3. *Lupinus arboreus*	15	No	UPL
4.			
5.			
Total Cover:	105 %		
Herb Stratum			
1. *Erharta erecta*	20	Yes	UPL
2. *Juncus effusus*	10	Yes	FACW
3. *Lobularia maritima*	5	No	UPL
4. *Epilobium ciliatum*	5	No	FACW
5. *Persicaria amphibia*	2	No	OBL
6. *Geranium molle*	2	No	UPL
7. *Oenanthe sarmentosa*	1	No	OBL
8.			
Total Cover:	45 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum 30 %   % Cover of Biotic Crust ____ %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50.0 % (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	3	x 1 =	3
FACW species	60	x 2 =	120
FAC species		x 3 =	0
FACU species	45	x 4 =	180
UPL species	42	x 5 =	210
Column Totals:	150 (A)		513 (B)

Prevalence Index = B/A = 3.42

Hydrophytic Vegetation Indicators:

- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? **Yes** ( ) **No** (●)

Remarks:

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SOIL

Sampling Point: 04

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 2/2	100						organic horizon + rocks
4-15	10YR 3/4	80	7.5YR 4/6	20	C	M	sandy	
15-18	5Y 4/2	70	7.5YR 4/6	30	C	M	sandy	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type:

Depth (inches):

Hydric Soil Present? **Yes** ○ **No** ●

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ● Depth (inches):

Water Table Present? Yes ○ No ● Depth (inches):

Saturation Present? (includes capillary fringe) Yes ● No ○ Depth (inches): 4

Wetland Hydrology Present? **Yes** ● **No** ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Soil is saturated in upper 12" due to combination of antecedent rains (12/2) and high water table. Lack of wetland vegetation and soil indicators suggest that soil saturation is not a prevalent condition at this location.

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements   City/County: Daly City, San Francisco Co.   Sampling Date: 12/03/12

Applicant/Owner: City of Daly City   State: CA   Sampling Point: 05

Investigator(s): M. Giolli, M. Lowe   Section, Township, Range: NA

Landform (hillslope, terrace, etc.): hillslope   Local relief (concave, convex, none): convex   Slope (%): 5

Subregion (LRR): C - Mediterranean California   Lat: 37.712336 N   Long: 122.488444 W   Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes   NWI classification: L1UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	(●)	( )
Hydric Soil Present?	( )	(●)
Wetland Hydrology Present?	( )	(●)

Is the Sampled Area within a Wetland? Yes ( ) No (●)

Remarks:

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Eriophyllum staechadifolium*	5	Yes	FACU
2. *Rubus ursinus*	5	Yes	FACU
3.			
4.			
5.			
Total Cover:	10 %		
Herb Stratum			
1. *Juncus balticus ssp. ater*	40	Yes	FACW
2. *Oenanthe sarmentosa*	30	Yes	OBL
3. *Epilobium ciliatum*	5	No	FACW
4. *Solanum nigrum*	10	No	FACU
5.			
6.			
7.			
8.			
Total Cover:	85 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum ____ %   % Cover of Biotic Crust ____ %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50.0 % (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	30	x 1 =	30
FACW species	45	x 2 =	90
FAC species		x 3 =	0
FACU species	20	x 4 =	80
UPL species		x 5 =	0
Column Totals:	95 (A)		200 (B)

Prevalence Index = B/A = 2.11

Hydrophytic Vegetation Indicators:

- ☐ Dominance Test is >50%
- ☒ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes (●) No ( )

Remarks:

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SOIL

Sampling Point: 05

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/3	100					sandy	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type:

Depth (inches):

Hydric Soil Present? Yes ○ No ◉

Remarks: No hydric soil indicators observed

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches):

Water Table Present? Yes ○ No ◉ Depth (inches):

Saturation Present? (includes capillary fringe) Yes ○ No ◉ Depth (inches):

Wetland Hydrology Present? Yes ○ No ◉

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No hydrology indicators observed. Sample pit is well above lake level.

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 12/03/12

Applicant/Owner: City of Daly City State: CA Sampling Point: 06

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): slope Local relief (concave, convex, none): convex Slope (%): 2

Subregion (LRR): C - Mediterranean California Lat: 37.712326 N Long: 122.488418 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: L1UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes (●)	No ( )
Wetland Hydrology Present?	Yes (●)	No ( )

Is the Sampled Area within a Wetland? Yes (●) No ( )

Remarks:

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1.			
2.			
3.			
4.			
5.			
Total Cover:	%		
Herb Stratum			
1. *Oenanthe sarmentosa*	45	Yes	OBL
2. *Juncus balticus spp. ater*	35	Yes	FACW
3. *Schoenoplectus californicus*	10	No	OBL
4. *Persicaria punctata*	2	No	OBL
5. *Persicaria amphibia*	2	No	OBL
6. *Epilobium ciliatum*	2	No	OBL
7.			
8.			
Total Cover:	96 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum 10 % % Cover of Biotic Crust %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0 % (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	61	x 1 =	61
FACW species	35	x 2 =	70
FAC species		x 3 =	0
FACU species		x 4 =	0
UPL species		x 5 =	0
Column Totals:	96 (A)		131 (B)

Prevalence Index = B/A = 1.36

Hydrophytic Vegetation Indicators:

- [x] Dominance Test is >50%
- [x] Prevalence Index is ≤3.0[1]
- [ ] Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- [ ] Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes (●) No ( )

Remarks:

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Exhibit 5

SOIL

Sampling Point: 06

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-5	10YR 2/1	100					sandy loam	
5-10	10YR 3/3	90	7.5YR 5/6	10	C	M	sandy	
10-15	2.5Y 3/1	75	10YR 4/6	25	C	M	sandy	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☒ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☒ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):
Type:
Depth (inches):

Hydric Soil Present? Yes ◉ No ○

Remarks: Given elevation of point relative to lake level and satisfaction of hydric vegetation indicator and wetland hydrology we assume this data point meets the technical criterion of 14 days saturation and that this is likely the upper edge of the wetland.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☒ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☒ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☒ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches):
Water Table Present?	Yes ◉	No ○	Depth (inches): 5
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): 1

Wetland Hydrology Present? **Yes** ◉ **No** ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Confirmation site visit 10.4.18
M.Giolli, R.Haines

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 12/03/12

Applicant/Owner: City of Daly City State: CA Sampling Point: 07

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR): C - Mediterranean California Lat: 37.709529 N Long: 122.487508 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: not mapped

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ( ) [underlined]	~~No~~ (●)
Hydric Soil Present?	Yes ( )	No (●) [underlined]
Wetland Hydrology Present?	~~Yes~~ (●)	No ( ) [underlined]

Is the Sampled Area within a Wetland? Yes ( ) No (●)

Remarks: Pit is above lake water level by about 6-8 inches/feet and 3 feet from water's edge.

Soil pit is 5-6 feet from waters edge; 3 feet vertically above lake level (2018).

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Rubus ursinus*	70	Yes	~~FACU~~ FAC
2.			
3.			
4.			
5.			
Total Cover:	70 %		
Herb Stratum			
1. *Persicaria amphibium*	30	Yes	OBL
2. ~~*Schoenoplectus californicus*~~	~~1~~	~~No~~	~~OBL~~
3.			
4.			
5.			
6.			
7.			
8.			
Total Cover:	~~31~~ % 30%		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum ____ % % Cover of Biotic Crust ____ %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 ~~1~~ (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ~~50.0~~ % (A/B) 100%

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	30 ~~31~~	x 1 =	~~31~~ 30
FACW species		x 2 =	0
FAC species		x 3 =	0
FACU species	70	x 4 =	280
UPL species		x 5 =	0
Column Totals:	100 ~~101~~ (A)		~~311~~ (B) 310

Prevalence Index = B/A = ~~3.08~~ 3.10

Hydrophytic Vegetation Indicators:

- Dominance Test is >50%
- Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes ( ) [underlined] ~~No~~ (●)

Remarks:

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SOIL

Sampling Point: 07

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
~~0-1~~	~~10YR 3/2~~	~~100~~						~~organic layer~~
~~1-18~~	~~2.5Y 3/3~~	~~100~~					~~sandy~~	
0-2	organic layer							
2-6	10 YR 4/3	100					sandy	
6+	rip rap - cannot dig beyond this layer							

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type:

Depth (inches):

Hydric Soil Present? Yes ○ **No** ●

Remarks: No hydric soil indicators observed. ~~Soil is saturated but redox was observed at most points with saturated soil.~~

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☒ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ●	Depth (inches):
Water Table Present?	~~Yes ●~~	No ○	Depth (inches): ~~7~~
Saturation Present? (includes capillary fringe)	~~Yes ●~~	No ○	Depth (inches): ~~to surface~~

Wetland Hydrology Present? ~~Yes ●~~ **No** ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Suspect soil saturation is due to antecedent rains combined with high water table.

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 12//12

Applicant/Owner: City of Daly City State: CA Sampling Point: 08

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): convex Slope (%): 3

Subregion (LRR): C - Mediterranean California Lat: 37.709127 N Long: 122.487054 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: not mapped

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes ( )	No (●)
Wetland Hydrology Present?	Yes (●)	No ( )

Is the Sampled Area within a Wetland? Yes ( ) No (●)

Remarks: Recent rains and inundation precluded a paired wetland point.

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Rubus ursinus*	35	Yes	FACU
2.			
3.			
4.			
5.			
Total Cover:	35 %		
Herb Stratum			
1. *Schoenoplectus californicus*	20	Yes	OBL
2. *Persicaria amphibia*	2	No	OBL
3.			
4.			
5.			
6.			
7.			
8.			
Total Cover:	22 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum ____ % % Cover of Biotic Crust ____ %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	1	(A)
Total Number of Dominant Species Across All Strata:	2	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	50.0 %	(A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	22	x 1 =	22
FACW species		x 2 =	0
FAC species		x 3 =	0
FACU species	35	x 4 =	140
UPL species		x 5 =	0
Column Totals:	57 (A)		162 (B)

Prevalence Index = B/A = 2.84

Hydrophytic Vegetation Indicators:

- ☐ Dominance Test is >50%
- ☒ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes (●) No ( )

Remarks: Pit is in unvegetated area mostly surrounded by vegetation. Wetland vegetation is within 5 foot radius but at lower elevation (about 2-3 feet) than sample point and therefore not rooted within the sample point).

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Exhibit 5

SOIL

Sampling Point: 08

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 2/2	100					sandy loam	lots of roots
3-12	10YR 3/2	100					sandy	
12-14	10YR 3/2	75	7.5YR 4/6	25	C	M	sandy	
14-18	10YR 3/1	100						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type:

Depth (inches):

Hydric Soil Present? **Yes** ○ **No** ◉

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches):
Water Table Present?	Yes ◉	No ○	Depth (inches): 12
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): 2

Wetland Hydrology Present? **Yes** ◉ **No** ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Given elevation relative to lake level and lack of wetland vegetation at elevation of sample pit, soil saturation assumed to be a result of antecedent rains and is not expected to persist for more than 14 consecutive days during the growing season.

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 12/03/12

Applicant/Owner: City of Daly City State: CA Sampling Point: 09

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): bank Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR): C - Mediterranean California Lat: 37.714104 N Long: 122.491108 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: PEMC

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ◉ No ○

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉	No ○
Hydric Soil Present?	Yes ◉	No ○
Wetland Hydrology Present?	Yes ◉	No ○

Is the Sampled Area within a Wetland? Yes ◉ No ○

Remarks: Pit is at water's edge.

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Salix lasiolepis*	25	Yes	FACW
2.			
3.			
4.			
5.			
Total Cover:	25 %		
Herb Stratum			
1. *Schoenoplectus californicus*	75	Yes	OBL
2. *Persicaria amphibia*	25	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
Total Cover:	100 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum ____ % % Cover of Biotic Crust ____ %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0 % (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	75	x 1 =	75
FACW species	50	x 2 =	100
FAC species		x 3 =	0
FACU species		x 4 =	0
UPL species		x 5 =	0
Column Totals:	125 (A)		175 (B)

Prevalence Index = B/A = 1.40

Hydrophytic Vegetation Indicators:

- ☒ Dominance Test is >50%
- ☒ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes ◉ No ○

Remarks:

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SOIL

Sampling Point: 09

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 2/2	100						organic layer
3-15	10YR 3/2	100					sandy	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☒ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):
Type:
Depth (inches):

Hydric Soil Present? **Yes** ◉ **No** ○

Remarks: Soil is highly saturated. may not show redox. Unconsolidated sandy sediment.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☒ Surface Water (A1)
- ☐ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☒ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☒ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ◉	No ○	Depth (inches): 0.5
Water Table Present?	Yes ◉	No ○	Depth (inches): at surface
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): to surface

Wetland Hydrology Present? **Yes** ◉ **No** ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 12/03/12

Applicant/Owner: City of Daly City State: CA Sampling Point: 10

Investigator(s): M. Giolli, M. Lowe Section, Township, Range: NA

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR): C - Mediterranean California Lat: 37.714101 N Long: 122.491127 W Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: PEMC

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes (●)	No ( )
Wetland Hydrology Present?	Yes (●)	No ( )

Is the Sampled Area within a Wetland? **Yes** (●) **No** ( )

Remarks:

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Salix laevigata*	45	Yes	FACW
2. *Rubus ursinus*	1	No	FACU
3.			
4.			
5.			
Total Cover:	46 %		
Herb Stratum			
1. *Persicaria amphibia*	50	Yes	OBL
2.			
3.			
4.			
5.			
6.			
7.			
8.			
Total Cover:	50 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum 50 % % Cover of Biotic Crust %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	2	(A)
Total Number of Dominant Species Across All Strata:	2	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	100.0 %	(A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	50	x 1 =	50
FACW species	45	x 2 =	90
FAC species		x 3 =	0
FACU species	1	x 4 =	4
UPL species		x 5 =	0
Column Totals:	96 (A)		144 (B)

Prevalence Index = B/A = 1.50

Hydrophytic Vegetation Indicators:

- ☒ Dominance Test is >50%
- ☒ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? **Yes** (●) **No** ( )

Remarks:

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SOIL

Sampling Point: 10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 2/2	90	10YR 4/6	10	C	M	sandy loam	
3-6	10YR 3/2	90	10YR 4/6	10	C	M	sandy	
6-15	10YR 3/2	100					sandy	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☒ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type:

Depth (inches):

Hydric Soil Present? Yes ◉ **No** ○

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches):
Water Table Present?	Yes ◉	No ○	Depth (inches): 7
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): 1

Wetland Hydrology Present? Yes ◉ **No** ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM - Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements — City/County: Daly City, San Francisco Co. — Sampling Date: 12/03/12

Applicant/Owner: City of Daly City — State: CA — Sampling Point: 11

Investigator(s): M. Giolli, M. Lowe — Section, Township, Range: NA

Landform (hillslope, terrace, etc.): terrace — Local relief (concave, convex, none): convex — Slope (%): 2

Subregion (LRR): C - Mediterranean California — Lat: 37.714044 N — Long: 122.491159 W — Datum: NAD 83

Soil Map Unit Name: Urban Land-Orthents, smoothed complex, 5 to 50 percent slopes — NWI classification: not mapped

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (•) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐ or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (•) No ( )

Are Vegetation ☐ Soil ☐ or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	(•)	( )
Hydric Soil Present?	( )	(•)
Wetland Hydrology Present?	(•)	( )

Is the Sampled Area within a Wetland? Yes ( ) No (•)

Remarks:

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:	%		
Sapling/Shrub Stratum			
1. *Salix lasiolepis*	30	Yes	FACW
2. *Lupinus arboreus*	10	No	UPL
3. *Rubus ursinus*	45	Yes	FACU
4.			
5.			
Total Cover:	85 %		
Herb Stratum			
1. *Persicaria amphibia*	40	Yes	OBL
2.			
3.			
4.			
5.			
6.			
7.			
8.			
Total Cover:	40 %		
Woody Vine Stratum			
1.			
2.			
Total Cover:	%		

% Bare Ground in Herb Stratum ____ % — % Cover of Biotic Crust ____ %

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 66.7 % (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	40	x 1 =	40
FACW species	30	x 2 =	60
FAC species		x 3 =	0
FACU species	45	x 4 =	180
UPL species	10	x 5 =	50
Column Totals:	125 (A)		330 (B)

Prevalence Index = B/A = 2.64

Hydrophytic Vegetation Indicators:

- ☒ Dominance Test is >50%
- ☒ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? Yes (•) No ( )

Remarks: leaf litter = 25% cover

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SOIL

Sampling Point: 11

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 2/2	100						organic layer
3-6	10YR 3/2	100					sandy	
6-18	10YR 3/2	90	7.5YR 4/6	10			sandy	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5) (**LRR C**)
- ☐ 1 cm Muck (A9) (**LRR D**)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) (**LRR C**)
- ☐ 2 cm Muck (A10) (**LRR B**)
- ☐ Reduced Vertic (F18)
- ☐ Red Parent Material (TF2)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):
Type:
Depth (inches):

Hydric Soil Present? Yes ○ No ◉

Remarks: No hydric soil criteria met, redox is below 6 inches only.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☒ Saturation (A3)
- ☐ Water Marks (B1) (**Nonriverine**)
- ☐ Sediment Deposits (B2) (**Nonriverine**)
- ☐ Drift Deposits (B3) (**Nonriverine**)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Salt Crust (B11)
- ☐ Biotic Crust (B12)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Plowed Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water Marks (B1) (**Riverine**)
- ☐ Sediment Deposits (B2) (**Riverine**)
- ☐ Drift Deposits (B3) (**Riverine**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches):
Water Table Present?	Yes ◉	No ○	Depth (inches): 18
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): 3

Wetland Hydrology Present? Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Given elevation relative to lake level saturation near surface is likely due to antecedent rains (12/2).

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 12

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): road bank toe Local relief (concave, convex, none): concave Slope (%): 2

Subregion (LRR): C Lat: 37.7158031161678 Long: -122.493445079126 Datum: NAD83

Soil Map Unit Name: Urban land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ______

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔	No ______
Hydric Soil Present?	Yes ✔	No ______
Wetland Hydrology Present?	Yes ✔	No ______

Is the Sampled Area within a Wetland? **Yes** ✔ **No** ______

Remarks:

point taken approx 20' away from overflow structure

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	
Sapling/Shrub Stratum (Plot size: 5x5m)			
1. Salix lasiolepis	30	Yes	FACW
2.			
3.			
4.			
5.			
	30	= Total Cover	
Herb Stratum (Plot size: 1m^2)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0	= Total Cover	
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	______	x 1 = 0
FACW species	______	x 2 = 0
FAC species	______	x 3 = 0
FACU species	______	x 4 = 0
UPL species	______	x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

✔ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** ✔ **No** ______

Remarks:

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Exhibit 5

SOIL

Sampling Point: SP 12

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-5	10YR 3/2	100					sandy loan	
5-18	10YR 3/1	94	2.5YR 4/6	3	C	M	clay loam	
			2.5YR 4/6	3	C	PL		

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ✔ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ____

Depth (inches): ____

Hydric Soil Present? Yes ✔ No ____

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ✔ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ✔ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ____ No ✔ Depth (inches): ____

Water Table Present? Yes ____ No ✔ Depth (inches): ____

Saturation Present? (includes capillary fringe) Yes ____ No ✔ Depth (inches): ____

Wetland Hydrology Present? Yes ✔ No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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Exhibit 5
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WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 13

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): road bank slope Local relief (concave, convex, none): concave Slope (%): 10

Subregion (LRR): C Lat: 37.7157557528514 Long: -122.493471406054 Datum: NAD83

Soil Map Unit Name: Urban land-Orthents, smoothed complex, 5 to 50 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	✔	
Hydric Soil Present?		✔
Wetland Hydrology Present?		✔

Is the Sampled Area within a Wetland? Yes ___ No ✔

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ___)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 5x5m)			
1. Salix lasiolepis	65	Yes	FACW
2. Rubus ursinus	4	No	FAC
3.			
4.			
5.			
	69 = Total Cover		
Herb Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 = Total Cover		
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species		x 3 = 0
FACU species		x 4 = 0
UPL species		x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

___ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ___ No ✔

Remarks:

2-23-0862

Exhibit 5

SOIL

Sampling Point: SP 13

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 3/2	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5) (**LRR C**)
___ 1 cm Muck (A9) (**LRR D**)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

___ 1 cm Muck (A9) (**LRR C**)
___ 2 cm Muck (A10) (**LRR B**)
___ Reduced Vertic (F18)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ✔

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1) (**Nonriverine**)
___ Sediment Deposits (B2) (**Nonriverine**)
___ Drift Deposits (B3) (**Nonriverine**)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Water-Stained Leaves (B9)
___ Salt Crust (B11)
___ Biotic Crust (B12)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water Marks (B1) (**Riverine**)
___ Sediment Deposits (B2) (**Riverine**)
___ Drift Deposits (B3) (**Riverine**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Crayfish Burrows (C8)
___ Saturation Visible on Aerial Imagery (C9)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No ✔ Depth (inches): ______
Water Table Present? Yes ______ No ✔ Depth (inches): ______
Saturation Present? (includes capillary fringe) Yes ______ No ✔ Depth (inches): ______

Wetland Hydrology Present? Yes ______ No ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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Exhibit 5

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 14

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): canal slope Local relief (concave, convex, none): concave Slope (%): 40

Subregion (LRR): C Lat: 37.7118689572779 Long: -122.489892775862 Datum: NAD83

Soil Map Unit Name: Orthents, cut and fill, 0 to 15 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?		✔
Hydric Soil Present?		✔
Wetland Hydrology Present?		✔

Is the Sampled Area within a Wetland? Yes ___ No ✔

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	
Sapling/Shrub Stratum (Plot size: 5x5m)			
1. Rubus ursinus	20	Yes	FAC
2.			
3.			
4.			
5.			
	20	= Total Cover	
Herb Stratum (Plot size: 1x1m)			
1. Bromus diandrus	15	Yes	UPL
2. Bromus hordeaceus	15	Yes	UPL
3. Briza maxima	10	Yes	UPL
4. Avena sp	5		UPL
5.			
6.			
7.			
8.			
	45	= Total Cover	
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 25 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species		x 3 = 0
FACU species		x 4 = 0
UPL species		x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

___ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ___ No ✔

Remarks:

just downhill of point it Rumex acetocella (FACU)

2-23-0862
Exhibit 5

SOIL

Sampling Point: SP 14

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 3/2	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ✔

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No ✔ Depth (inches): ______

Water Table Present? Yes ______ No ✔ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ______ No ✔ Depth (inches): ______

Wetland Hydrology Present? Yes ______ No ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

2-23-0862
Exhibit 5
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WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 15

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): none Slope (%): 2

Subregion (LRR): C Lat: 37.7146409583109 Long: -122.492701460267 Datum: NAD83

Soil Map Unit Name: Orthents, cut and fill, 0 to 15 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔	No ___
Hydric Soil Present?	Yes ___	No ✔
Wetland Hydrology Present?	Yes ___	No ✔

Is the Sampled Area within a Wetland? **Yes** ___ **No** ✔

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ___)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
= Total Cover	0		
Sapling/Shrub Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
5.			
= Total Cover	0		
Herb Stratum (Plot size: 1x1m)			
1. Rubus ursinus	30	Yes	FAC
2. Amsinckia sp.	10	Yes	UPL
3. Scrophularia californica	20	Yes	FAC
4. Raphanus sativus	5	Yes	UPL
5.			
6.			
7.			
8.			
= Total Cover	65		
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
= Total Cover	0		

% Bare Ground in Herb Stratum ___ % Cover of Biotic Crust ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 40 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species		x 3 = 0
FACU species		x 4 = 0
UPL species		x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

✔ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** ✔ **No** ___

Remarks:

2-23-0862
Exhibit 5

SOIL

Sampling Point: SP 15

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 3/2	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? Yes ______ No ✔

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No ✔ Depth (inches): ____________

Water Table Present? Yes ______ No ✔ Depth (inches): ____________

Saturation Present? (includes capillary fringe) Yes ______ No ✔ Depth (inches): ____________

Wetland Hydrology Present? Yes ______ No ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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Exhibit 5
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WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 16

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): none Slope (%): 2

Subregion (LRR): C Lat: 37.7146409583109 Long: -122.492701460267 Datum: NAD83

Soil Map Unit Name: Orthents, cut and fill, 0 to 15 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?		✔
Hydric Soil Present?		✔
Wetland Hydrology Present?		✔

Is the Sampled Area within a Wetland? **Yes** ___ **No** ✔

Remarks:

point taken at top of canal bank

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 1x1m)			
1. Soleirolia soleirolii	10	Yes	UPL
2. Parietaria judiaca	40	Yes	UPL
3. Delairea odorata	20	Yes	FAC
4.			
5.			
6.			
7.			
8.			
	70 = Total Cover		
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 33 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species		x 3 = 0
FACU species		x 4 = 0
UPL species		x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

___ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** ___ **No** ✔

Remarks:

2-23-0862
Exhibit 5

SOIL

Sampling Point: SP 16

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 3/2	100					sand	
6-12	10YR 3/2	99	2.5YR 3/8	1	C	M	sandy loan	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ✔

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No ✔ Depth (inches): ______

Water Table Present? Yes ______ No ✔ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ______ No ✔ Depth (inches): ______

Wetland Hydrology Present? Yes ______ No ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

soil is saturated first 0.25", but not deeper, likely due to morning dew/fog

2-23-0862
Exhibit 5

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 17

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): hill slope Local relief (concave, convex, none): none Slope (%): 3

Subregion (LRR): C Lat: 37.714806908184 Long: -122.492940987898 Datum: NAD83

Soil Map Unit Name: Orthents, cut and fill, 0 to 15 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔	No ___	**Is the Sampled Area within a Wetland?** Yes ___ No ✔
Hydric Soil Present?	Yes ___	No ✔	
Wetland Hydrology Present?	Yes ___	No ✔	

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
	0	= Total Cover	
Sapling/Shrub Stratum (Plot size: 5x5m)			
1. Rubus ursinus	80	Yes	FAC
2.			
3.			
4.			
5.			
	80	= Total Cover	
Herb Stratum (Plot size: 1m^2)			
1. Delairea odorata	1		FAC
2. Raphanus sativus	5	Yes	UPL
3. Parietaria diffusa	2	Yes	UPL
4. Epilobium brachycarpum	2	Yes	FAC
5. Festuca bromoides	1		UPL
6. Torilis arvensis	1		UPL
7. Rumex crispus	1		FAC
8.			FAC
	13	= Total Cover	
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species		x 3 = 0
FACU species		x 4 = 0
UPL species		x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

✔ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✔ No ___

Remarks:

2-23-0862

Exhibit 5

SOIL

Sampling Point: SP 17

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 3/2	100					sandy loan	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5) (**LRR C**)
___ 1 cm Muck (A9) (**LRR D**)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

___ 1 cm Muck (A9) (**LRR C**)
___ 2 cm Muck (A10) (**LRR B**)
___ Reduced Vertic (F18)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ✔

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1) (**Nonriverine**)
___ Sediment Deposits (B2) (**Nonriverine**)
___ Drift Deposits (B3) (**Nonriverine**)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Water-Stained Leaves (B9)
___ Salt Crust (B11)
___ Biotic Crust (B12)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water Marks (B1) (**Riverine**)
___ Sediment Deposits (B2) (**Riverine**)
___ Drift Deposits (B3) (**Riverine**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Crayfish Burrows (C8)
___ Saturation Visible on Aerial Imagery (C9)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No ✔ Depth (inches): ______

Water Table Present? Yes ______ No ✔ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ______ No ✔ Depth (inches): ______

Wetland Hydrology Present? Yes ______ No ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

2-23-0862
Exhibit 5

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 18

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): hill slope Local relief (concave, convex, none): none Slope (%): 2

Subregion (LRR): C Lat: 37.7150730919231 Long: -122.493295055191 Datum: NAD83

Soil Map Unit Name: Orthents, cut and fill, 0 to 15 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔ No ___	**Is the Sampled Area within a Wetland?**	**Yes ___ No ✔**
Hydric Soil Present?	Yes ___ No ✔		
Wetland Hydrology Present?	Yes ___ No ✔		

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ___)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 5x5m)			
1. Salix lasiolepis	60	Yes	FACW
2. Rubus ursinus	85	Yes	FAC
3.			
4.			
5.			
	145 = Total Cover		
Herb Stratum (Plot size: 1x1m)			
1. Fumaria sp.	2	No	UPL
2. Delairea odorata	5	Yes	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	7 = Total Cover		
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species		x 3 = 0
FACU species		x 4 = 0
UPL species		x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

✔ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes ✔ No ___**

Remarks:

2-23-0862
Exhibit 5

SOIL

Sampling Point: SP 18

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 3/2	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5) (**LRR C**)
___ 1 cm Muck (A9) (**LRR D**)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

___ 1 cm Muck (A9) (**LRR C**)
___ 2 cm Muck (A10) (**LRR B**)
___ Reduced Vertic (F18)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ✔

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1) (**Nonriverine**)
___ Sediment Deposits (B2) (**Nonriverine**)
___ Drift Deposits (B3) (**Nonriverine**)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Water-Stained Leaves (B9)
___ Salt Crust (B11)
___ Biotic Crust (B12)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water Marks (B1) (**Riverine**)
___ Sediment Deposits (B2) (**Riverine**)
___ Drift Deposits (B3) (**Riverine**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Crayfish Burrows (C8)
___ Saturation Visible on Aerial Imagery (C9)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No ✔ Depth (inches): ______
Water Table Present? Yes ______ No ✔ Depth (inches): ______
Saturation Present? (includes capillary fringe) Yes ______ No ✔ Depth (inches): ______

Wetland Hydrology Present? Yes ______ No ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

2-23-0862
Exhibit 5

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Vista Grande Drainage Basin Improvements City/County: Daly City, San Francisco Co. Sampling Date: 07/08/2020

Applicant/Owner: City of Daly City State: CA Sampling Point: SP 19

Investigator(s): Joseph Sanders and Nicole Ibanez Section, Township, Range: ______

Landform (hillslope, terrace, etc.): hill slope Local relief (concave, convex, none): none Slope (%): 2

Subregion (LRR): C Lat: 37.7106600206155 Long: -122.488171410137 Datum: NAD83

Soil Map Unit Name: Orthents, cut and fill, 0 to 15 percent slopes NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	✔	
Hydric Soil Present?		✔
Wetland Hydrology Present?		✔

Is the Sampled Area within a Wetland? Yes ___ No ✔

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 5x5m)			
1. Salix lasiolepis	60	Yes	FACW
2. Rubus ursinus	10	No	FAC
3.			
4.			
5.			
	70 = Total Cover		
Herb Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 = Total Cover		
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species		x 3 = 0
FACU species		x 4 = 0
UPL species		x 5 = 0
Column Totals:	0 (A)	0 (B)

Prevalence Index = B/A = NaN

Hydrophytic Vegetation Indicators:

✔ Dominance Test is >50%
___ Prevalence Index is ≤3.0[1]
___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✔ No ___

Remarks:

2-23-0862
Exhibit 5

SOIL

Sampling Point: SP 19

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 3/2	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5) (**LRR C**)
___ 1 cm Muck (A9) (**LRR D**)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

___ 1 cm Muck (A9) (**LRR C**)
___ 2 cm Muck (A10) (**LRR B**)
___ Reduced Vertic (F18)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: __________

Depth (inches): __________

Hydric Soil Present? Yes ____ No ✔

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1) (**Nonriverine**)
___ Sediment Deposits (B2) (**Nonriverine**)
___ Drift Deposits (B3) (**Nonriverine**)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Water-Stained Leaves (B9)
___ Salt Crust (B11)
___ Biotic Crust (B12)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water Marks (B1) (**Riverine**)
___ Sediment Deposits (B2) (**Riverine**)
___ Drift Deposits (B3) (**Riverine**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Crayfish Burrows (C8)
___ Saturation Visible on Aerial Imagery (C9)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ____ No ✔ Depth (inches): ________

Water Table Present? Yes ____ No ✔ Depth (inches): ________

Saturation Present? (includes capillary fringe) Yes ____ No ✔ Depth (inches): ________

Wetland Hydrology Present? Yes ____ No ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

2-23-0862
Exhibit 5
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APPENDIX C

Jurisdictional Determination Analysis Map and Jurisdictional Determination for the Vista Grande Canal

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DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, U.S. ARMY CORPS OF ENGINEERS
1455 MARKET STREET, 16TH FLOOR
SAN FRANCISCO, CALIFORNIA 94103-1398

APR 2 5 2016

RECEIVED
MAY 0 2 2016
DWWR

Regulatory Division

Subject: File Number 2014-00030S

Mr. Patrick Sweetland
Director, Daly City Department of Water
153 Lake Merced Boulevard
Daly City, California 94015

Dear Mr. Sweetland:

This correspondence is in reference to your submittal of September 19, 2014, concerning whether there is a requirement for Department of the Army (DA) authorization to discharge fill material in a man-made, brick-lined trapezoidal channel created in dryland (Vista Grande Channel) for the proposed Vista Grande Drainage Basin Improvement Project in Daly City, San Mateo County, California.

All proposed discharges of dredged or fill material occurring below the plane of ordinary high water in non-tidal waters of the United States (U.S.) or below the high tide line in tidal waters of the U.S. and within the lateral extent of wetlands adjacent to these waters, typically require DA authorization and the issuance of a permit under Section 404 of the Clean Water Act of 1972, as amended (33 U.S.C. § 1344 *et seq.*). All proposed structures and work, including: excavation, dredging, and discharges of dredged or fill material, occurring below the plane of mean high water in tidal waters of the U.S.; in former diked baylands currently below mean high water; outside the limits of mean high water but affecting the navigable capacity of tidal waters; or below the plane of ordinary high water in non-tidal waters designated as navigable waters of the U.S., typically require DA authorization and the issuance of a permit under Section 10 of the Rivers and Harbors Act of 1899, as amended (33 U.S.C. § 403 *et seq.*). Navigable waters of the U.S. generally include all waters subject to the ebb and flow of the tide; and/or all waters presently used, or have been used in the past, or may be susceptible for future use to transport interstate or foreign commerce.

Under the Preamble for 33 CFR Part 328.3 (Definitions), "the Corps generally does not consider non-tidal drainage ditches and irrigation ditches excavated on dry land to meet the definition of waters of the United States." "However, the Corps reserves the right on a case-by-case basis to determine that a particular waterbody within these categories of waters is a water of the United States." Based on historic maps, the Vista Grande Channel is a man-made channel which was excavated in dryland that did not follow any natural drainage feature or intersect a natural tributary. In consideration of the age of the channel, the brick and concrete lined invert and the relatively low physical and biological functions, the Vista Grande Channel in the project site is not considered a water of the United States. Therefore, the proposed discharges of fill material in the Vista Grande

Channel will not result in the placement of fill materials within waters or wetlands subject to Corps regulation and no DA permit would be required.

This approved jurisdictional determination is based on the current conditions of the site, as verified during a field investigation of April 10, 2014, and a review of other data included in your submittal. This approved jurisdictional determination will expire in five years from the date of this letter, unless new information or a change in field conditions warrants a revision to the delineation map prior to the expiration date. The basis for this approved jurisdictional determination is further explained in the enclosed Approved Jurisdictional Determination Form. This approved jurisdictional determination is presumed to be consistent with the official interagency guidance of June 5, 2007, interpreting the Supreme Court decision, Rapanos v. United States, 126 S. Ct. 2208 (2006).

This determination does not obviate the need to obtain other Federal, State, or local approvals required by law, including compliance with the Federal Endangered Species Act (ESA) (16 U.S.C. § 1531 *et seq.*). Even though this activity is not prohibited by, or otherwise subject to regulation under section 404 of the Clean Water Act, the take of a threatened or endangered species as defined under the ESA is not authorized. In the absence of a separate authorization from the U.S. Fish and Wildlife Service or the National Marine Fisheries Service, both lethal and non-lethal takes of protected species are a violation of the ESA. Similarly, the appropriate State of California, Regional Water Quality Control Board may still regulate your proposed activity because of impacts to a "water of the State". Therefore, you should also contact appropriate Federal, State and local regulatory authorities to determine whether your activity may require other authorizations or permits.

This determination will expire in five years from the date of this letter, unless new information or a change in project design or field conditions warrants further review prior to the expiration date. You may refer any questions on this matter to Katerina Galacatos of my Regulatory staff by telephone at (415) 503-6778 or by e-mail at greg.brown@usace.army.mil. All correspondence should be addressed to the Regulatory Division, South Branch, referencing the file number at the head of this letter.

The San Francisco District is committed to improving service to our customers. My Regulatory staff seeks to achieve the goals of the Regulatory Program in an efficient and cooperative manner, while preserving and protecting our nation's aquatic resources. If you would like to provide comments on our Regulatory Program, please complete the Customer Service Survey Form available on our website: https://www.spn.usace.army.mil/Missions/Regulatory.aspx.

Sincerely,

Aaron O. Allen, Ph.D.
Acting Chief, Regulatory Division

Enclosure

Copy Furnished (w/ encl 1 only):

CA RWQCB, Oakland, CA

APPROVED JURISDICTIONAL DETERMINATION FORM
U.S. Army Corps of Engineers

This form should be completed by following the instructions provided in Section IV of the JD Form Instructional Guidebook.

SECTION I: BACKGROUND INFORMATION

A. REPORT COMPLETION DATE FOR APPROVED JURISDICTIONAL DETERMINATION (JD): 06 April 2016

B. DISTRICT OFFICE, FILE NAME, AND NUMBER: San Francisco District, Vista Grande Channel, SPN-2014-00030 S

C. PROJECT LOCATION AND BACKGROUND INFORMATION:

State: CA County/parish/borough: San Mateo City: Daly City
Center coordinates of site (lat/long in degree decimal format): Lat. 37.71535° N, Long. -122.49458° W.
Universal Transverse Mercator:
Name of nearest waterbody: Pacific Ocean.
Name of nearest Traditional Navigable Water (TNW) into which the aquatic resource flows: San Francisco Bay
Name of watershed or Hydrologic Unit Code (HUC): N/A

☒ Check if map/diagram of review area and/or potential jurisdictional areas is/are available upon request.
☐ Check if other sites (e.g., offsite mitigation sites, disposal sites, etc…) are associated with this action and are recorded on a different JD form.

D. REVIEW PERFORMED FOR SITE EVALUATION (CHECK ALL THAT APPLY):

☒ Office (Desk) Determination. Date: 6 April 2016
☒ Field Determination. Date(s): 15 April 2014

SECTION II: SUMMARY OF FINDINGS

A. RHA SECTION 10 DETERMINATION OF JURISDICTION.

There **Are no** "*navigable waters of the U.S.*" within Rivers and Harbors Act (RHA) jurisdiction (as defined by 33 CFR part 329) in the review area. [*Required*]

☐ Waters subject to the ebb and flow of the tide.
☐ Waters are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. Explain:

B. CWA SECTION 404 DETERMINATION OF JURISDICTION.

There **Are no** "*waters of the U.S.*" within Clean Water Act (CWA) jurisdiction (as defined by 33 CFR part 328) in the review area. [*Required*]

1. **Waters of the U.S.**

   a. **Indicate presence of waters of U.S. in review area (check all that apply):** [1]

   ☐ TNWs, including territorial seas
   ☐ Wetlands adjacent to TNWs
   ☐ Relatively permanent waters[2] (RPWs) that flow directly or indirectly into TNWs
   ☐ Non-RPWs that flow directly or indirectly into TNWs
   ☐ Wetlands directly abutting RPWs that flow directly or indirectly into TNWs
   ☐ Wetlands adjacent to but not directly abutting RPWs that flow directly or indirectly into TNWs
   ☐ Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs
   ☐ Impoundments of jurisdictional waters
   ☐ Isolated (interstate or intrastate) waters, including isolated wetlands

   b. **Identify (estimate) size of waters of the U.S. in the review area:**
   Non-wetland waters: 0linear feet: 0width (ft) and/or 0 acres.
   Wetlands: 0 acres.

   c. **Limits (boundaries) of jurisdiction** based on: **Not Applicable**
   Elevation of established OHWM (if known): N/A.

2. Non-regulated waters/wetlands (check if applicable):[3]

   ☒ Potentially jurisdictional waters and/or wetlands were assessed within the review area and determined to be not jurisdictional. Explain: **The Vista Grande Channel/Canal is a 3,600-foot-long, man-made, brick lined trapezoidal channel located in the City and County of San Francisco and in Daly City within the County of San Mateo (see attached Maps 5-8 dated August 2014). The storm water conveyance channel was constructed in the 1890s and is designed for a maximum discharge capacity of approximately 500 cfs. The channel conveys storm flows as well as low flows consisting of**

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[1] Boxes checked below shall be supported by completing the appropriate sections in Section III below.
[2] For purposes of this form, an RPW is defined as a tributary that is not a TNW and that typically flows year-round or has continuous flow at least "seasonally" (e.g., typically 3 months).
[3] Supporting documentation is presented in Section III.F.

irrigation runoff from surrounding landscaped areas. Upstream of the storm water conveyance channel, the 1,690-acre watershed is heavily urbanized with numerous storm drains. At the upstream end of the channel, a large storm drain outlets into the Vista Grande Channel. At the terminus of the channel is the inlet for the 3,000-foot-long Vista Grande Tunnel, which has a capacity of 170 cfs and conveys storm flows to the Pacific Ocean. The underground storm drain system upstream of the channel as well as the downstream underground Vista Grande Tunnel are currently regulated as a point source discharge under a regional municipal storm water NPDES permit issued by the Regional Board. Prior to urban development in the Daly City area, natural drainages conveyed surface runoff to Lake Merced, which were replaced with underground storm drains with increased urbanization. Based on historic maps, the Vista Grande Channel is a man-made channel which was excavated in dryland that did not follow any natural drainage feature or intersect a natural tributary. The channel invert consists of bricks and cement and, due to the relatively large amount of impervious surfaces in the watershed, the channel supports relatively limited sediment transport. The upper banks of the trapezoidal channel are earthen and support opportunistic annual grasses, non-native trees and primarily horticultural shrubs. At the time of the field delineation, open water in the channel varied from approximately 4 to 9 feet in width and approximately 2 to 4 inches in depth. The primary hydrological source for the channel is upstream storm drains with only limited local runoff from upland areas adjacent to the channel. Due to the brick-lined invert and disturbed buffer areas, the drainage feature supports relatively low physical functions and services. The upstream watershed has been heavily modified and is dominated by impervious surfaces, resulting in relatively low hydrologic functions and services. Vegetation in the vicinity of the channel is dominated by annual grasses and non-native trees resulting in limited habitat functions and services. Overall, the Vista Grande Channel has been in place for over 100 years and exhibits relatively low physical and biological functions. Under the Preamble for 33 CFR Part 328.3 (Definitions), "the Corps generally does not consider non-tidal drainage and irrigation ditches excavated on dry land to meet the definition of waters of the United States." "However, the Corps reserves the right on a case-by-case basis to determine that a particular waterbody within these categories of waters is a water of the United States." Based on the above information, Vista Grande Channel meets the requirements of the language in the preamble and would usually not be considered to be a water of the United States. The 2007 Rapanos Guidance discusses the jurisdictional status of ditches on page 11. " In addition, ditches (including roadside ditches) excavated wholly in and draining only uplands and that do not carry a relatively permanent flow of water are generally not waters of the United States because they are not tributaries or they do not have a significant nexus to downstream traditional navigable waters." The Preamble language for non-tidal drainage and irrigation ditches does not reference a flow regime and, as a result, under the Preamble language a perennial drainage ditch is usually not considered a water of the United States. The above information concerning application of the Preamble language to perennial drainage features was confirmed in discussions with Regulatory HQ and regional technical experts for delineating waters of the United States. Due to past disturbance in the vicinity of the channel, the presence of adjacent roadways and dense residential development and impervious surfaces in the watershed that have reduced and impaired buffer areas and modified the surface hydrology substantially, the Vista Grande Channel exhibits relatively low physical and biological functions. In consideration of the specific site conditions present in the vicinity of the Vista Grande Channel, the drainage channel is non-jurisdictional under the language in the Preamble and a permit is not required for discharges of fill material in Vista Grande Channel.

SECTION III: CWA ANALYSIS

A. TNWs AND WETLANDS ADJACENT TO TNWs

The agencies will assert jurisdiction over TNWs and wetlands adjacent to TNWs. If the aquatic resource is a TNW, complete Section III.A.1 and Section III.D.1. only; if the aquatic resource is a wetland adjacent to a TNW, complete Sections III.A.1 and 2 and Section III.D.1.; otherwise, see Section III.B below.

1. TNW
   Identify TNW: .

   Summarize rationale supporting determination: .

2. Wetland adjacent to TNW
   Summarize rationale supporting conclusion that wetland is "adjacent": .

B. CHARACTERISTICS OF TRIBUTARY (THAT IS NOT A TNW) AND ITS ADJACENT WETLANDS (IF ANY):

This section summarizes information regarding characteristics of the tributary and its adjacent wetlands, if any, and it helps determine whether or not the standards for jurisdiction established under *Rapanos* have been met.

The agencies will assert jurisdiction over non-navigable tributaries of TNWs where the tributaries are "relatively permanent waters" (RPWs), i.e. tributaries that typically flow year-round or have continuous flow at least seasonally (e.g., typically 3 months). A wetland that directly abuts an RPW is also jurisdictional. If the aquatic resource is not a TNW, but has year-round (perennial) flow, skip to Section III.D.2. If the aquatic resource is a wetland directly abutting a tributary with perennial flow, skip to Section III.D.4.

A wetland that is adjacent to but that does not directly abut an RPW requires a significant nexus evaluation. Corps districts and EPA regions will include in the record any available information that documents the existence of a significant nexus between a relatively permanent tributary that is not perennial (and its adjacent wetlands if any) and a traditional navigable water, even though a significant nexus finding is not required as a matter of law.

If the waterbody[4] is not an RPW, or a wetland directly abutting an RPW, a JD will require additional data to determine if the waterbody has a significant nexus with a TNW. If the tributary has adjacent wetlands, the significant nexus evaluation must consider the tributary in combination with all of its adjacent wetlands. This significant nexus evaluation that combines, for analytical purposes, the tributary and all of its adjacent wetlands is used whether the review area identified in the JD request is the tributary, or its adjacent wetlands, or both. If the JD covers a tributary with adjacent wetlands, complete Section III.B.1 for the tributary, Section III.B.2 for any onsite wetlands, and Section III.B.3 for all wetlands adjacent to that tributary, both onsite and offsite. The determination whether a significant nexus exists is determined in Section III.C below.

1. Characteristics of non-TNWs that flow directly or indirectly into TNW

   (i) General Area Conditions:
   Watershed size: Pick List
   Drainage area: Pick List
   Average annual rainfall: 4.25 inches
   Average annual snowfall: 0.9 inches

   (ii) Physical Characteristics:
   (a) Relationship with TNW:
   ☐ Tributary flows directly into TNW.
   ☐ Tributary flows through Pick List tributaries before entering TNW.

   Project waters are Pick List river miles from TNW.
   Project waters are Pick List river miles from RPW.
   Project waters are Pick List aerial (straight) miles from TNW.
   Project waters are Pick List aerial (straight) miles from RPW.
   Project waters cross or serve as state boundaries. Explain: .

   Identify flow route to TNW[5]: .
   Tributary stream order, if known:

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[4] Note that the Instructional Guidebook contains additional information regarding swales, ditches, washes, and erosional features generally and in the arid West.
[5] Flow route can be described by identifying, e.g., tributary a, which flows through the review area, to flow into tributary b, which then flows into TNW.

(b) General Tributary Characteristics (check all that apply):

Tributary is: ☐ Natural
☐ Artificial (man-made). Explain: .
☐ Manipulated (man-altered). Explain: .

Tributary properties with respect to top of bank (estimate):
Average width: feet
Average depth: feet
Average side slopes: Pick List.

Primary tributary substrate composition (check all that apply):

☐ Silts ☐ Sands ☐ Concrete
☐ Cobbles ☐ Gravel ☐ Muck
☐ Bedrock ☐ Vegetation. Type/% cover:
☐ Other. Explain: .

Tributary condition/stability [e.g., highly eroding, sloughing banks]. Explain:
Presence of run/riffle/pool complexes. Explain: .
Tributary geometry: Pick List
Tributary gradient (approximate average slope): %

(c) Flow:
Tributary provides for: Pick List
Estimate average number of flow events in review area/year: Pick List
Describe flow regime: .
Other information on duration and volume: .

Surface flow is: Pick List. Characteristics: .

Subsurface flow: Pick List. Explain findings: .
☐ Dye (or other) test performed: .

Tributary has (check all that apply):
☐ Bed and banks
☐ OHWM[6] (check all indicators that apply):

☐ clear, natural line impressed on the bank ☐ the presence of litter and debris
☐ changes in the character of soil ☐ destruction of terrestrial vegetation
☐ shelving ☐ the presence of wrack line
☐ vegetation matted down, bent, or absent ☐ sediment sorting
☐ leaf litter disturbed or washed away ☐ scour
☐ sediment deposition ☐ multiple observed or predicted flow events
☐ water staining ☐ abrupt change in plant community
☐ other (list):

☐ Discontinuous OHWM.[7] Explain: .

If factors other than the OHWM were used to determine lateral extent of CWA jurisdiction (check all that apply):
☒ High Tide Line indicated by: ☐ Mean High Water Mark indicated by:
☐ oil or scum line along shore objects ☐ survey to available datum;
☐ fine shell or debris deposits (foreshore) ☐ physical markings;
☐ physical markings/characteristics ☐ vegetation lines/changes in vegetation types.
☐ tidal gauges
☐ other (list):

(iii) Chemical Characteristics:
Characterize tributary (e.g., water color is clear, discolored, oily film; water quality; general watershed characteristics, etc.).
Explain:
Identify specific pollutants, if known: .

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[6]A natural or man-made discontinuity in the OHWM does not necessarily sever jurisdiction (e.g., where the stream temporarily flows underground, or where the OHWM has been removed by development or agricultural practices). Where there is a break in the OHWM that is unrelated to the waterbody's flow regime (e.g., flow over a rock outcrop or through a culvert), the agencies will look for indicators of flow above and below the break.
[7]Ibid.

(iv) **Biological Characteristics. Channel supports (check all that apply):**

- ☐ Riparian corridor. Characteristics (type, average width): .
- ☐ Wetland fringe. Characteristics: .
- ☐ Habitat for:
  - ☐ Federally Listed species. Explain findings: .
  - ☐ Fish/spawn areas. Explain findings:
  - ☐ Other environmentally-sensitive species. Explain findings: .
  - ☐ Aquatic/wildlife diversity. Explain findings:

2. **Characteristics of wetlands adjacent to non-TNW that flow directly or indirectly into TNW**

(i) **Physical Characteristics:**

(a) General Wetland Characteristics:

Properties:

Wetland size: acres

Wetland type. Explain: .

Wetland quality. Explain: .

Project wetlands cross or serve as state boundaries. Explain: .

(b) General Flow Relationship with Non-TNW:

Flow is: Pick List. Explain: .

Surface flow is: Pick List

Characteristics: .

Subsurface flow: Pick List. Explain findings: .

- ☐ Dye (or other) test performed: .

(c) Wetland Adjacency Determination with Non-TNW:

- ☐ Directly abutting
- ☐ Not directly abutting
  - ☐ Discrete wetland hydrologic connection. Explain: .
  - ☐ Ecological connection. Explain:
  - ☐ Separated by berm/barrier. Explain: .

(d) Proximity (Relationship) to TNW

Project wetlands are Pick List river miles from TNW.

Project waters are Pick List aerial (straight) miles from TNW.

Flow is from: Pick List.

Estimate approximate location of wetland as within the Pick List floodplain.

(ii) **Chemical Characteristics:**

Characterize wetland system (e.g., water color is clear, brown, oil film on surface; water quality; general watershed characteristics; etc.). Explain:

Identify specific pollutants, if known: .

(iii) **Biological Characteristics. Wetland supports (check all that apply):**

- ☐ Riparian buffer. Characteristics (type, average width): .
- ☐ Vegetation type/percent cover. Explain: .
- ☐ Habitat for:
  - ☐ Federally Listed species. Explain findings: .
  - ☐ Fish/spawn areas. Explain findings: .
  - ☐ Other environmentally-sensitive species. Explain findings: .
  - ☐ Aquatic/wildlife diversity. Explain findings: .

3. **Characteristics of all wetlands adjacent to the tributary (if any)**

All wetland(s) being considered in the cumulative analysis: Pick List

Approximately ( ) acres in total are being considered in the cumulative analysis.

For each wetland, specify the following:

Directly abuts? (Y/N)	Size (in acres)	Directly abuts? (Y/N)	Size (in acres)

Summarize overall biological, chemical and physical functions being performed .

C. **SIGNIFICANT NEXUS DETERMINATION**

A significant nexus analysis will assess the flow characteristics and functions of the tributary itself and the functions performed by any wetlands adjacent to the tributary to determine if they significantly affect the chemical, physical, and biological integrity of a TNW. For each of the following situations, a significant nexus exists if the tributary, in combination with all of its adjacent wetlands, has more than a speculative or insubstantial effect on the chemical, physical and/or biological integrity of a TNW. Considerations when evaluating significant nexus include, but are not limited to the volume, duration, and frequency of the flow of water in the tributary and its proximity to a TNW, and the functions performed by the tributary and all its adjacent wetlands. It is not appropriate to determine significant nexus based solely on any specific threshold of distance (e.g. between a tributary and its adjacent wetland or between a tributary and the TNW). Similarly, the fact an adjacent wetland lies within or outside of a floodplain is not solely determinative of significant nexus.

Draw connections between the features documented and the effects on the TNW, as identified in the *Rapanos* Guidance and discussed in the Instructional Guidebook. Factors to consider include, for example:

- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to carry pollutants or flood waters to TNWs, or to reduce the amount of pollutants or flood waters reaching a TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), provide habitat and lifecycle support functions for fish and other species, such as feeding, nesting, spawning, or rearing young for species that are present in the TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to transfer nutrients and organic carbon that support downstream foodwebs?
- Does the tributary, in combination with its adjacent wetlands (if any), have other relationships to the physical, chemical, or biological integrity of the TNW?

Note: the above list of considerations is not inclusive and other functions observed or known to occur should be documented below:

1. **Significant nexus findings for non-RPW that has no adjacent wetlands and flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary itself, then go to Section III.D:

2. **Significant nexus findings for non-RPW and its adjacent wetlands, where the non-RPW flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

3. **Significant nexus findings for wetlands adjacent to an RPW but that do not directly abut the RPW.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

D. **DETERMINATIONS OF JURISDICTIONAL FINDINGS. THE SUBJECT WATERS/WETLANDS ARE (CHECK ALL THAT APPLY):**

1. **TNWs and Adjacent Wetlands.** Check all that apply and provide size estimates in review area:
   ☒ TNWs: linear feet width (ft), Or, acres.
   ☒ Wetlands adjacent to TNWs: acres.

2. **RPWs that flow directly or indirectly into TNWs.**
   ☐ Tributaries of TNWs where tributaries typically flow year-round are jurisdictional. Provide data and rationale indicating that tributary is perennial: .
   ☒ Tributaries of TNW where tributaries have continuous flow "seasonally" (e.g., typically three months each year) are jurisdictional. Data supporting this conclusion is provided at Section III.B. Provide rationale indicating that tributary flows seasonally: .

Provide estimates for jurisdictional waters in the review area (check all that apply):
- ☐ Tributary waters: linear feet width (ft).
- ☐ Other non-wetland waters: acres.
  Identify type(s) of waters:

3. **Non-RPWs[8] that flow directly or indirectly into TNWs.**
   ☐ Waterbody that is not a TNW or an RPW, but flows directly or indirectly into a TNW, and it has a significant nexus with a TNW is jurisdictional. Data supporting this conclusion is provided at Section III.C.

   Provide estimates for jurisdictional waters within the review area (check all that apply):
   - ☐ Tributary waters: linear feet width (ft).
   - ☐ Other non-wetland waters: acres.
     Identify type(s) of waters: .

4. **Wetlands directly abutting an RPW that flow directly or indirectly into TNWs.**
   ☐ Wetlands directly abut RPW and thus are jurisdictional as adjacent wetlands.
   - ☐ Wetlands directly abutting an RPW where tributaries typically flow year-round. Provide data and rationale indicating that tributary is perennial in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW: .

   - ☐ Wetlands directly abutting an RPW where tributaries typically flow "seasonally." Provide data indicating that tributary is seasonal in Section III.B and rationale in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW:

   Provide acreage estimates for jurisdictional wetlands in the review area: acres.

5. **Wetlands adjacent to but not directly abutting an RPW that flow directly or indirectly into TNWs.**
   ☐ Wetlands that do not directly abut an RPW, but when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisidictional. Data supporting this conclusion is provided at Section III.C.

   Provide acreage estimates for jurisdictional wetlands in the review area: acres.

6. **Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs.**
   ☐ Wetlands adjacent to such waters, and have when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisdictional. Data supporting this conclusion is provided at Section III.C.

   Provide estimates for jurisdictional wetlands in the review area: acres.

7. **Impoundments of jurisdictional waters.[9]**
   As a general rule, the impoundment of a jurisdictional tributary remains jurisdictional.
   - ☐ Demonstrate that impoundment was created from "waters of the U.S.," or
   - ☐ Demonstrate that water meets the criteria for one of the categories presented above (1-6), or
   - ☐ Demonstrate that water is isolated with a nexus to commerce (see E below).

E. ISOLATED [INTERSTATE OR INTRA-STATE] WATERS, INCLUDING ISOLATED WETLANDS, THE USE, DEGRADATION OR DESTRUCTION OF WHICH COULD AFFECT INTERSTATE COMMERCE, INCLUDING ANY SUCH WATERS (CHECK ALL THAT APPLY):[10]
- ☐ which are or could be used by interstate or foreign travelers for recreational or other purposes.
- ☐ from which fish or shellfish are or could be taken and sold in interstate or foreign commerce.
- ☐ which are or could be used for industrial purposes by industries in interstate commerce.
- ☐ Interstate isolated waters. Explain: .
- ☐ Other factors. Explain: .

Identify water body and summarize rationale supporting determination: .

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[8] See Footnote # 3.
[9] To complete the analysis refer to the key in Section III.D.6 of the Instructional Guidebook.
[10] **Prior to asserting or declining CWA jurisdiction based solely on this category, Corps Districts will elevate the action to Corps and EPA HQ for review consistent with the process described in the Corps/EPA *Memorandum Regarding CWA Act Jurisdiction Following Rapanos.***

Provide estimates for jurisdictional waters in the review area (check all that apply):
☒ Tributary waters: linear feet width (ft).
☒ Other non-wetland waters: acres.
Identify type(s) of waters: .
☒ Wetlands: acres.

F. **NON-JURISDICTIONAL WATERS, INCLUDING WETLANDS (CHECK ALL THAT APPLY):**
☐ If potential wetlands were assessed within the review area, these areas did not meet the criteria in the 1987 Corps of Engineers Wetland Delineation Manual and/or appropriate Regional Supplements.
☒ Review area included isolated waters with no substantial nexus to interstate (or foreign) commerce.
☐ Prior to the Jan 2001 Supreme Court decision in "*SWANCC*," the review area would have been regulated based <u>solely</u> on the "Migratory Bird Rule" (MBR).
☒ Waters do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction. Explain: .
☒ Other: (explain, if not covered above): : **Application of the Preamble language for 33 CFR Part 328.3 is discretionary and is applied on a case-by-case basis. In consideration of the age of the channel, the brick and concrete invert and the relatively low physical and biological functions, the Vista Grande Drainage Channel in the project site is not considered a water of the United States and no permit is required for discharges of fill material in the drainage feature.**

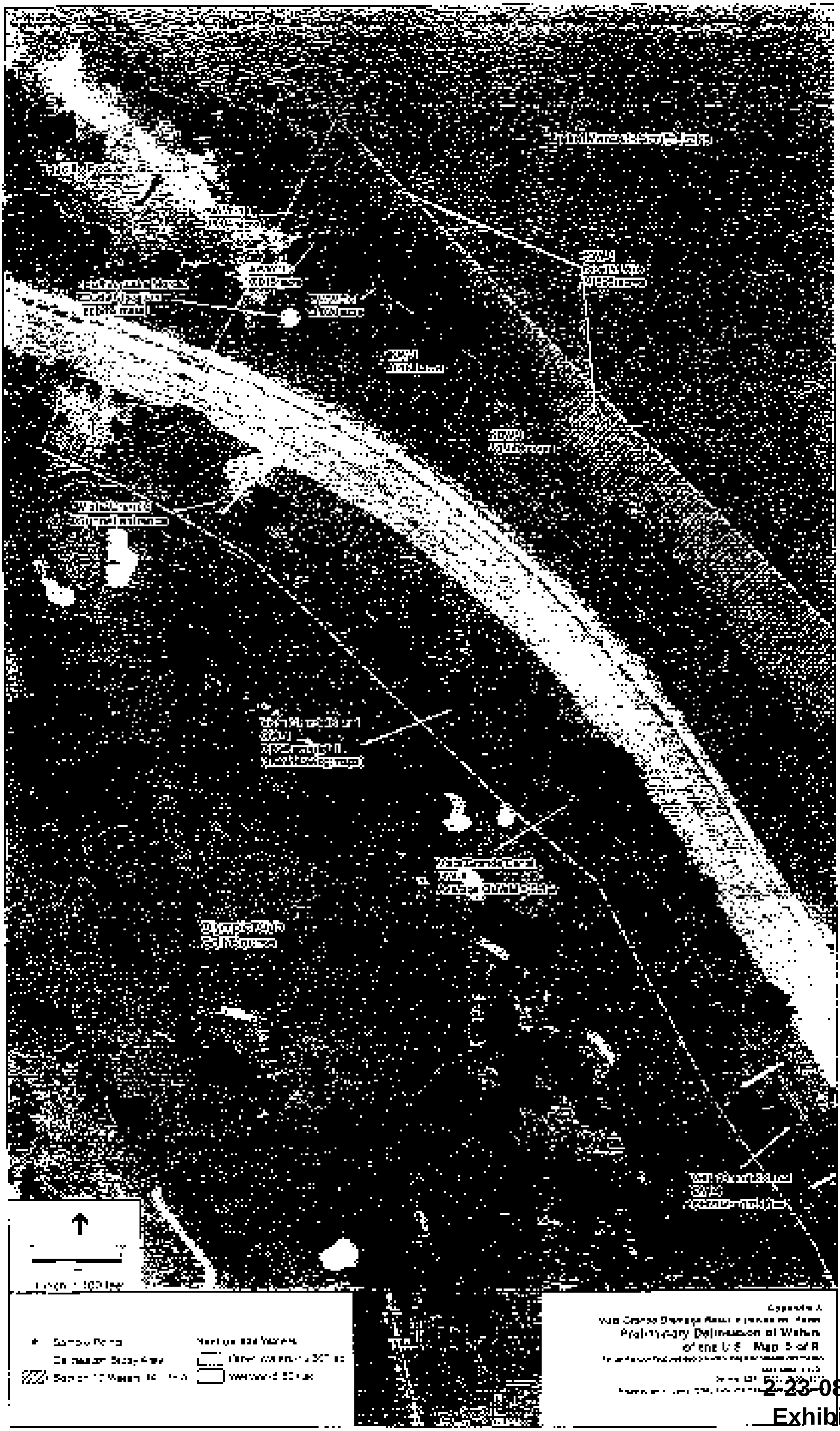
Provide acreage estimates for non-jurisdictional waters in the review area, where the <u>sole</u> potential basis of jurisdiction is the MBR factors (i.e., presence of migratory birds, presence of endangered species, use of water for irrigated agriculture), using best professional judgment (check all that apply):
☒ Non-wetland waters (i.e., rivers, streams): linear feet width (ft).
☒ Lakes/ponds: acres.
☒ Other non-wetland waters: acres. List type of aquatic resource: .
☒ Wetlands: acres.

Provide acreage estimates for non-jurisdictional waters in the review area that do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction (check all that apply):
☒ Non-wetland waters (i.e., rivers, streams): linear feet, width (ft).
☒ Lakes/ponds: acres.
☒ Other non-wetland waters: acres. List type of aquatic resource: .
☒ Wetlands: acres.

<u>SECTION IV: DATA SOURCES</u>.

A. **SUPPORTING DATA. Data reviewed for JD (check all that apply** - checked items shall be included in case file and, where checked and requested, appropriately reference sources below):
☒ Maps, plans, plots or plat submitted by or on behalf of the applicant/consultant: LSA Jurisdictional Determination Reports dated January 2014 and September 2014.
☒ Data sheets prepared/submitted by or on behalf of the applicant/consultant.
☒ Office concurs with data sheets/delineation report.
☐ Office does not concur with data sheets/delineation report.
☒ Data sheets prepared by the Corps: .
☒ Corps navigable waters' study: .
☒ U.S. Geological Survey Hydrologic Atlas: .
☐ USGS NHD data.
☐ USGS 8 and 12 digit HUC maps.
☒ U.S. Geological Survey map(s). Cite scale & quad name:1:24000,
☒ USDA Natural Resources Conservation Service Soil Survey. Citation:Figure 3 in Delineation Report
☒ National wetlands inventory map(s). Cite name: .
☒ State/Local wetland inventory map(s): .
☒ FEMA/FIRM maps:Exhibit IV-4 of the Terra Nova/ Town of Apple Valley General Plan
☒ 100-year Floodplain Elevation is: (National Geodectic Vertical Datum of 1929)
☒ Photographs: ☒ Aerial (Name & Date):Figure 5 in Delineation Report, Google earth © Google 2015, ORM map tool, and USGS National Map Viewer.
or ☒ Other (Name & Date):Site photographs in JD Report.
☒ Previous determination(s). File no. and date of response letter: .
☒ Applicable/supporting case law: Memo dated March 3, 2016.
☒ Applicable/supporting scientific literature: .
☒ Other information (please specify): .

B. ADDITIONAL COMMENTS TO SUPPORT JD: See above, Section B(2).



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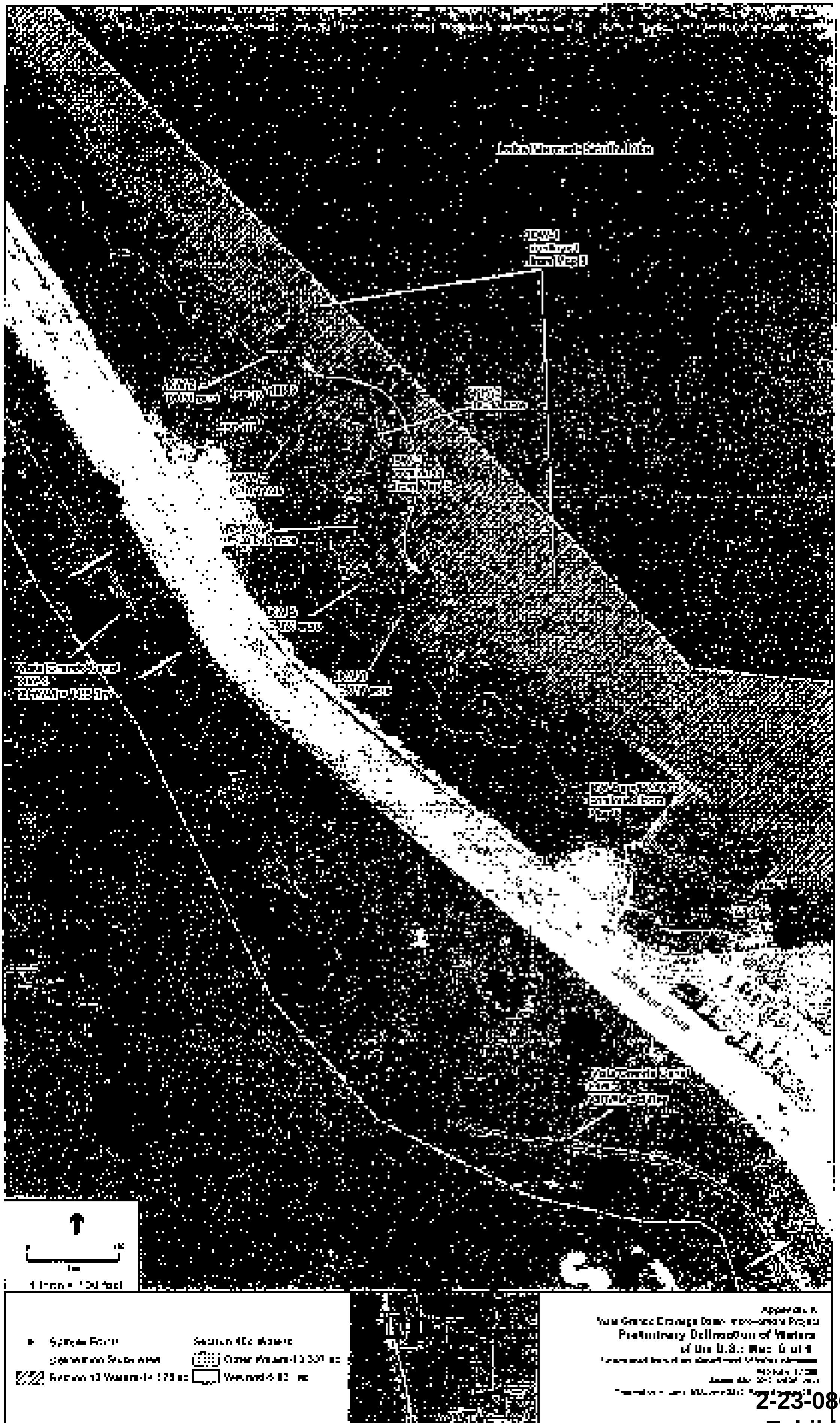
Preliminary Delineation of Waters

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Exhibit 5
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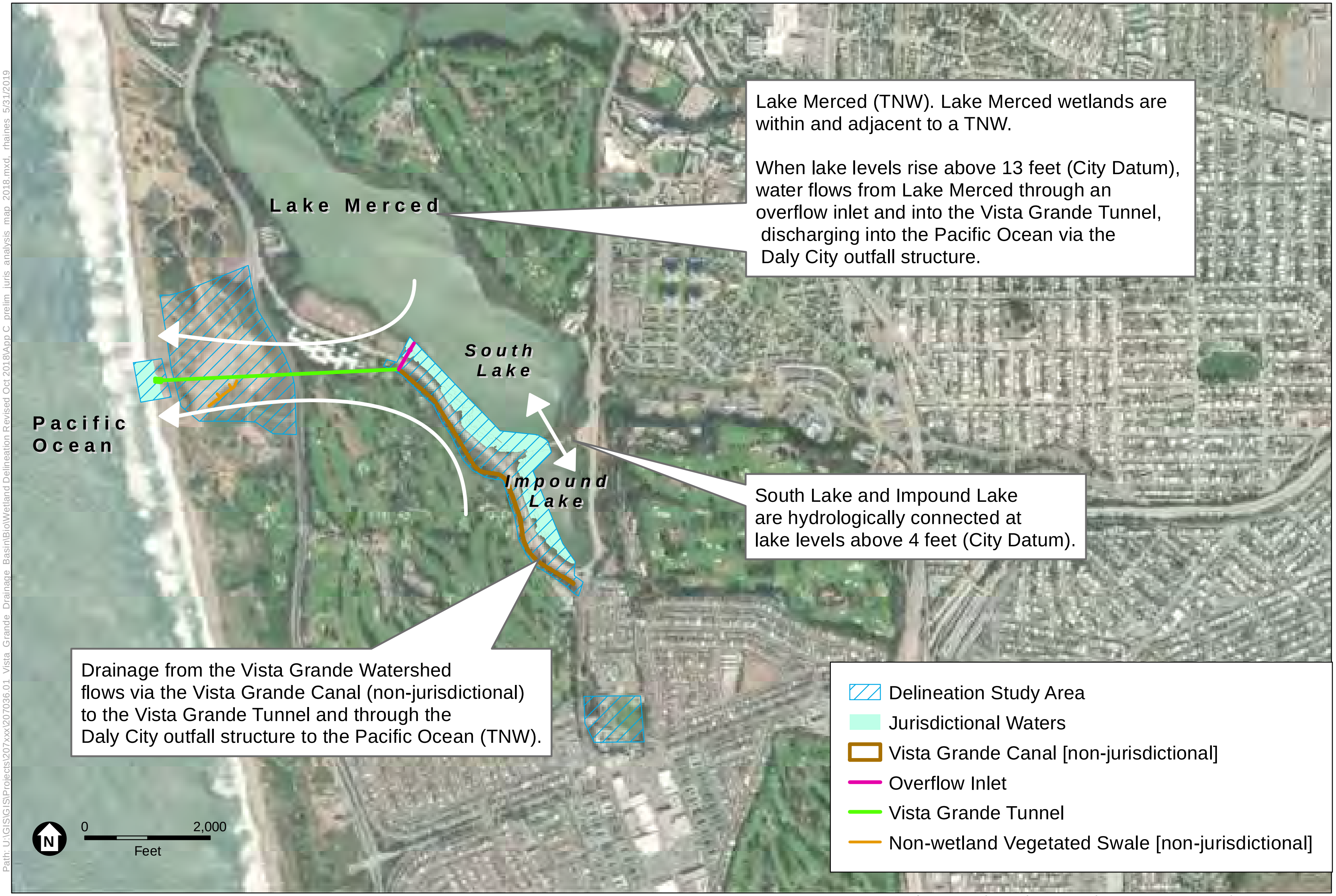
Lake Merced Blvd
1 inch = 100 feet
Sample Points
Section 404 Waters
Appendix A
Preliminary Delineation of Waters
of the U.S. Map 8 of 9

A-12



Path: U:\GIS\GIS\Projects\207xxx\207036.01 Vista Grande Drainage Basin\Bio\Wetland Delineation Revised Oct 2018\App C prelim juris analysis map 2018.mxd, rhaines 5/31/2019

SOURCE: ESA, 2014, 2018

Vista Grande Drainage Basin Improvement Project.207036.01

Figure C-1
Preliminary Jurisdictional Analysis Map

ESA

APPENDIX D

Soils Map

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SOURCE: USGS; Microsoft Corporation, 2013

Vista Grande Drainage Basin Improvement Project . 207036.01

Appendix D

Soils Mapped in the Delineation Study Area

APPENDIX E

WETS Tables for San Francisco County

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WETS Station : SAN FRANCISCO RICHMOND, CA7767 Creation Date: 08/29/2002
Latitude: 3746 Longitude: 12230 Elevation: 00030
State FIPS/County(FIPS): 06075 County Name: San Francisco
Start yr. - 1971 End yr. - 2000

Month	Temperature (Degrees F.) avg daily max	Temperature (Degrees F.) avg daily min	Temperature (Degrees F.) avg	Precipitation (Inches) avg	30% chance will have less than	30% chance will have more than	avg # of days w/.1 or more	avg total snow fall
January	57.5	43.9	50.7	4.18	1.98	5.10	7	0.0
February	59.8	46.0	52.9	3.78	1.60	4.68	7	0.0
March	60.3	46.9	53.6	3.13	1.27	3.94	6	0.0
April	61.1	47.7	54.4	1.12	0.32	1.39	2	0.0
May	61.5	49.5	55.5	0.53	0.02	0.59	1	0.0
June	62.8	51.6	57.2	0.09	0.00	0.11	0	0.0
July	63.7	53.8	58.7	0.03	0.00	0.00	0	0.0
August	64.6	54.7	59.7	0.09	0.00	0.04	0	0.0
September	66.3	54.5	60.4	0.18	0.00	0.21	0	0.0
October	66.0	52.4	59.2	0.91	0.24	1.13	1	0.0
November	62.0	48.0	55.0	2.64	0.92	3.17	4	0.0
December	58.0	44.2	51.1	2.91	1.52	3.62	5	0.0
Annual	-----	-----	-----	------	9.91	20.07	--	----
Average	62.0	49.4	55.7	------	------	------	--	----
Total	-----	-----	-----	19.60	------	------	33	0.0

GROWING SEASON DATES

Probability	Temperature: 24 F or higher	Temperature: 28 F or higher	Temperature: 32 F or higher
	Beginning and Ending Dates Growing Season Length		
50 percent *	---------- > 365 days	---------- > 365 days	> 365 days > 365 days
70 percent *	---------- > 365 days	---------- > 365 days	> 365 days > 365 days

* Percent chance of the growing season occurring between the Beginning and Ending dates.

total 1948-2002 prcp

Station : CA7767, SAN FRANCISCO RICHMOND
------- Unit = inches

yr	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	annl
48							0.00	0.01	0.03	0.24	0.93	M4.93	6.14
49	M2.19	M2.42	5.20	0.00	1.68	0.00	0.05	0.02	0.00	0.15	M1.65	2.44	15.80
50	6.63	M2.77	1.90	1.09	0.29	0.11	0.00	0.00	0.00	2.99	5.35	5.86	26.99
51	3.86	3.10	1.45	0.73	0.66		0.00		0.05				9.85
59	3.75	4.74	0.39	0.74	0.03	0.00	0.00	0.00	2.05	0.06	0.00	1.61	13.37
60	4.25	3.25	2.09	1.24	1.05	0.00	0.00	0.00	0.00	0.48	2.85	2.59	17.80
61	2.42	M1.35	2.59	0.82	0.68	0.00	0.00	0.03	0.20	0.09	4.70	2.14	15.02
62	1.33	7.17	2.36	0.54	0.00	0.00	0.00	0.00	0.15	7.94	0.00	3.75	23.24
63	4.45	2.00	4.65	3.23	0.55	0.00	0.00	0.00	0.36	1.78	3.12	M0.86	21.00
64	3.45	0.29	1.79	0.02	0.18	0.52	0.06	0.00	0.00	1.58	3.75	5.25	16.89
65	4.49	0.96	2.71	3.57	0.00	0.01	0.00	1.20	0.00	0.00	5.19	3.81	21.94
66	3.35	3.30	0.70	0.72	0.25	0.22	0.02	0.31	0.10	0.00	4.82	3.74	17.53
67	10.17	0.45	4.26	5.24	0.15	1.89	0.00	0.00	0.05	0.68	1.02	2.11	26.02
68	5.02	2.77	3.41	0.26	0.16	0.00	0.01	0.10	0.05	0.73	3.26	4.87	20.64
69	M7.36	7.20	1.00	1.87	0.02	0.05	0.00	0.00	0.10	2.84	0.93	5.96	27.33
70	7.67	2.15	1.94	0.03	0.12	0.80	0.00	0.00	0.00	0.79	6.58	5.62	25.70

71	2.22	0.38	3.25	0.97	0.42	0.04	0.01	0.01	0.22	0.13	1.66	4.42	13.73
72	1.24	1.50	0.29	0.99	0.00	0.14	0.00	0.04	0.80	4.87	5.97	3.06	18.90
73	9.26	6.29	2.44	0.01	0.08	0.00	0.00	0.00	0.33	1.64	7.30	4.11	31.46
74	3.96	1.84	5.35	2.30	0.00	0.14	0.55	0.00	0.00	0.65	0.35	2.25	17.39
75	2.41	4.91	5.48	0.93	0.04	0.00	0.22	0.03	0.00	2.10	0.46	0.45	17.03
76	0.40	2.02	1.07	2.68	0.08	0.01	0.00	0.69	0.15	0.48	1.20	3.02	11.80
77	1.53	0.72	2.22	0.04	0.64	0.00	0.00	0.02	0.49	0.15	2.57	3.38	11.76
78			4.98	3.91	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.62	10.64
79	M0.00			M0.00	M0.00	0.00	0.00	0.00	0.00	1.58			1.58
80				1.15	M0.00	0.00	0.00	0.00	0.00	0.00	0.47	1.79	3.41
81	4.74	1.99	4.36	0.10	0.20	0.00		0.00	0.33	M0.00	5.04	5.53	22.29
82		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54		5.82		6.36
83	5.64	7.83	9.74	2.83	0.56		M0.00	0.16	0.28	0.82	2.19	6.15	36.20
84	0.60	2.07	0.00				M0.21				6.75	2.07	11.70
85				M0.00	0.03	0.00	0.05					1.59	1.67
86	4.80	7.99	5.71		0.14	0.00	0.00		0.00				18.64
88					0.66	0.35	0.00	M0.00	0.00	0.68		4.09	5.78
89	1.22	1.32	5.11	0.68	0.02	0.10	0.00	0.07	M1.13	1.21	1.45	0.00	12.31
90	2.98	1.96	1.04	0.46	1.90	0.00	0.00	0.00	0.02	0.14	0.52	1.71	10.73
91	0.48	3.76	6.03	1.01	0.50	0.12	0.00	0.48	0.00	1.80	0.33	3.08	17.59
92	M1.14	5.35	4.41	0.45	0.00	M0.32	0.00	M0.02	M0.00		0.38	M4.65	16.72
93	9.97	4.08	M1.83	0.55	M0.84		0.00			0.30	M2.22	M2.09	21.88
94	M2.01	M3.37	0.15	0.91	M1.24	0.05	0.00	0.00	0.10	0.06	4.74	3.02	15.65
95	9.06	0.74	6.87	1.43	0.61	0.53	0.00	0.00	0.00	0.05	0.02	6.88	26.19
96	5.58	4.75	1.27	1.80	1.66	0.00	0.00	0.00	0.02	0.95	M3.19	6.72	25.94
97	8.00	0.22	0.30	0.32	0.15	0.32	0.00	0.75	0.06	0.76	6.69	2.39	19.96
98	9.15	13.90	2.48	1.31	3.68	0.03	0.00	0.00	0.03	0.70	3.57	M0.95	35.80
99	3.67	5.47	1.98	2.09	0.06	0.06	0.00	0.02	0.04	0.67	1.31	0.38	15.75
0	5.97	8.24	2.00	2.07	1.29	0.10	0.00	0.00	0.24	2.21	M0.69	0.53	23.34
1	3.05	5.70	1.14	1.54	0.00	M0.08	0.00	0.00	M0.10	0.30	M4.86	M9.44	26.21
2													

WETS Station : SAN FRAN MISSION DOLORE, CA7772   Creation Date: 08/29/2002
Latitude: 3746   Longitude: 12226   Elevation: 00080
State FIPS/County(FIPS): 06075   County Name: San Francisco
Start yr. - 1971   End yr. - 2000

Month	Temperature (Degrees F.)			Precipitation (Inches)				
					30% chance will have		avg # of days w/.1 or more	avg total snow fall
	avg daily max	avg daily min	avg	avg	less than	more than		
January	57.5	46.4	51.9	4.53	2.27	5.53	8	0.0
February	60.9	48.5	54.7	4.00	1.79	4.87	7	0.0
March	62.0	49.2	55.6	3.25	1.48	3.97	6	0.0
April	64.1	50.1	57.1	1.22	0.51	1.49	3	0.0
May	64.9	51.4	58.2	0.55	0.06	0.62	1	0.0
June	67.2	53.2	60.2	0.13	0.00	0.15	0	0.0
July	67.7	54.4	61.0	0.03	0.00	0.00	0	0.0
August	68.7	55.6	62.1	0.09	0.00	0.06	0	0.0
September	70.9	56.1	63.5	0.28	0.00	0.35	1	0.0
October	70.1	54.6	62.3	1.15	0.40	1.43	2	0.0
November	63.6	50.8	57.2	3.20	1.11	3.84	5	0.0
December	58.0	46.7	52.4	3.05	1.69	3.78	6	0.0
Annual	-----	-----	-----	------	16.80	24.79	--	----
Average	64.6	51.4	58.0	------	------	------	--	----
Total	-----	-----	-----	21.47	------	------	39	0.0

GROWING SEASON DATES

Probability	Temperature		
	24 F or higher	28 F or higher	32 F or higher
	Beginning and Ending Dates Growing Season Length		
50 percent *	----------	----------	----------

70 percent *	> 365 days ---------- > 365 days	> 365 days ---------- > 365 days	> 365 days ---------- > 365 days

* Percent chance of the growing season occurring between the Beginning and Ending dates.

total 1948-2002 prcp

Station : CA7772, SAN FRAN MISSION DOLORE
------- Unit = inches

yr	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	annl
48							0.02	0.02	0.09	0.20	1.18	4.76	6.27
49	2.20	3.04	5.85	0.00	0.93	0.00	0.06	0.04	0.00	0.08	1.18	2.77	16.15
50	7.40	2.33	1.65	0.87	0.37	0.03	0.00	0.00	0.00	2.72	4.96	6.01	26.34
51	4.41	3.00	1.32	0.89	0.65	0.04	0.01	0.43	0.08	0.81	3.33	7.92	22.89
52	10.69	2.62	4.90	1.08	0.30	0.39	0.00	0.01	0.00	0.07	2.42	9.06	31.54
53	3.26	0.04	1.83	3.42	0.38	0.61	0.00	0.07	0.00	0.34	1.88	0.82	12.65
54	3.11	2.42	4.56	0.82	0.11	0.14	0.03	0.20	0.00	0.24	2.55	5.67	19.85
55	4.05	1.18	0.29	1.49	0.04	0.00	0.02	0.00	0.02	0.03	2.38	11.47	20.97
56	8.72	2.03	0.12	1.68	0.68	0.02	0.00	0.01	0.33	1.14	0.04	0.37	15.14
57	2.84	3.58	2.39	1.09	3.19	0.06	0.01	0.00	1.46	3.46	1.13	3.60	22.81
58	4.38	7.78	8.22	5.47	0.88	0.09	0.05	0.00	0.04	0.12	0.09	1.48	28.60
59	3.96	4.04	0.30	0.36	0.02	0.00	0.00	0.02	2.06	0.00	0.00	1.71	12.47
60	4.04	3.57	2.06	1.16	0.85	0.00	0.00	0.00	0.00	0.48	3.35	2.31	17.82
61	2.79	0.96	2.27	0.79	0.88	0.04	0.00	0.02	0.22	0.09	4.44	2.13	14.63
62	1.08	6.58	2.76	0.36	0.00	0.00	0.00	0.07	0.22	5.51	0.60	2.81	19.99
63	3.35	1.92	3.87	3.35	0.45	0.00	0.00	0.00	0.06	1.39	3.52	0.87	18.78
64	3.37	0.19	2.12	0.01	0.22	0.57	0.00	0.01	0.00	1.90	3.99	5.35	17.73
65	3.97	0.94	2.92	3.21	0.00	0.00	0.02	0.49	0.00	0.01	4.79	3.51	19.86
66	3.27	2.72	0.80	0.36	0.19	0.17	0.06	0.10	0.10	0.01	4.80	3.87	16.45
67	9.49	0.22	4.35	4.90	0.09	1.42	0.00	0.00	0.04	0.53	1.10	2.12	24.26
68	4.54	2.28	3.15	0.48	0.22	0.00	0.00	0.03	0.06	0.62	2.67	3.91	17.96
69	7.74	7.26	1.01	1.74	0.00	0.05	0.00	0.00	0.01	2.61	0.45	6.15	27.02
70	7.81	1.56	1.55	0.06	0.03	0.57	0.00	0.00	0.00	0.84	6.44	5.39	24.25
71	2.04	0.26	2.91	0.72	0.19	0.00	0.01	0.01	0.22	0.11	1.92	3.93	12.32
72	1.32	2.13	0.23	1.07	0.00	0.11	0.01	0.04	0.54	5.41	6.40	3.53	20.79
73	9.38	6.32	2.63	0.02	0.08	0.00	0.00	0.00	0.30	1.62	7.80	3.65	31.80
74	3.40	1.53	4.49	2.34	0.00	0.10	0.62	0.00	0.00	0.85	0.40	1.53	15.26
75	2.57	3.72	5.15	1.25	0.02	0.04	0.20	0.02	0.00	2.44	0.43	0.18	16.02
76	0.31	1.83	1.01	0.70	0.01	0.03	0.00	0.78	0.51	0.38	1.04	2.13	8.73
77	1.65	0.90	2.01	0.05	0.57	0.00	0.00	0.03	0.86	0.17	1.96	3.30	11.50
78	6.20	3.54	5.20	3.82	0.00	0.00	0.00	0.00	0.20	0.00	1.67	0.89	21.52
79	6.74	4.96	1.58	0.87	0.15	0.00	0.07	0.00	0.01	1.66	2.98	3.10	22.12
80	3.77	4.84	1.25	0.97	0.23	0.02	0.04	0.00	0.00	0.00	0.14	2.95	14.21
81	4.00	1.78	3.71	0.17	0.12	0.00	0.00	0.00	0.22	1.74	3.73	4.15	19.62
82	6.84	3.26	7.65	3.03	0.00	0.06	0.00	0.00	0.72	2.79	5.62	2.22	32.19
83	5.77	8.06	9.04	3.48	0.47	0.00	0.01	0.06	0.68	0.26	8.20	7.72	43.75
84	0.50	2.34	1.32	0.92	0.16	0.30	0.00	0.24	0.10	2.94	7.45	2.10	18.37
85	0.59	1.98	3.94	0.27	0.09	0.31	0.00	0.00	0.38	0.80	4.83	2.47	15.66
86	4.77	8.29	6.25	0.76	0.13	0.00	0.03	0.01	1.32	0.11	0.20	1.64	23.51
87	4.26	3.77	2.31	0.14	0.06	0.01	0.00	0.00	0.00	1.07	3.09	5.09	19.80
88	4.93	0.40	0.07	1.73	0.66	0.70	0.00	0.00	0.00	0.64	3.70	4.23	17.06
89	1.26	1.49	5.28	0.70	0.06	0.07	0.00	0.05	0.98	1.18	1.33	0.00	12.40
90	4.02	2.45	1.34	0.58	2.38	0.01	0.00	0.04	0.12	0.20	0.52	1.94	13.60
91	0.60	3.29	5.89	1.07	0.36	0.05	0.00	0.42	0.00	2.35	0.50	2.32	16.85
92	2.09	6.34	4.41	0.38	0.00	0.39	0.00	0.02	0.00	1.16	0.40	6.03	21.22
93	9.82	4.48	2.90	0.71	0.87	0.27	0.00	0.00	0.00	0.33	2.16	2.25	23.79
94	2.77	4.87	0.35	1.12	1.31	0.06	0.00	0.00	0.22	0.33	10.49	2.69	24.21
95	8.97	0.24	7.88	1.61	0.97	0.62	0.00	0.00	0.00	0.06	0.08	8.13	28.56
96	6.71	5.28	1.28	1.56	1.79	0.00	0.00	0.00	0.04	1.05	4.72	7.61	30.04
97	7.59	0.32	0.58	0.29	0.16	0.30	0.00	0.73	0.04	1.00	6.97	2.77	20.75
98	12.08	14.89	2.54	2.13	3.92	0.15	0.01	0.01	0.09	0.91	4.02	1.42	42.17
99	4.41	7.35	2.34	2.62	0.23	0.12	0.00	0.10	0.59	0.65	2.32	0.62	21.35
0	6.41	8.96	2.04	1.66	1.40	0.16	0.02	0.02	0.21	2.38	0.85	0.90	25.01
1	3.76	7.73	1.58	1.89	0.00	0.15	0.01	0.05	0.18	0.51	5.18	10.75	31.79
2													

APPENDIX F

Representative Photographs

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Photo 1: Iceplant and remnant coastal dune scrub within the project area at Fort Funston (11/07/12)

Photo 2: Overview of project area on Ocean Beach (11/07/12)

SOURCE: ESA, 2012

Figure B-1
Representative Photographs

Photo 3: Vegetated swale at Fort Funston collects parking lot runoff (11/07/12)

Photo 4: Downstream end of vegetated swale, which discharges into culvert and sewer system (11/07/12)

SOURCE: ESA, 2012

Figure B-2
Representative Photographs

Photo 5: Upstream end of Vista Grande Canal shows typical wide reach of canal with OHWM of 11.5 feet (11/07/12)

Photo 6: Typical narrow reach of Vista Grande Canal with OHWM of 5 feet (11/07/12)

SOURCE: ESA, 2012

Figure B-3
Representative Photographs

Photo 7: The OHWM of Vista Grande canal is approximately 8" above the channel bed (11/07/12)

Photo 8: Downstream end of Vista Grande Canal, with trash rack and tunnel entry (11/07/12)

SOURCE: ESA, 2012

Figure B-4
Representative Photographs

Photo 9: Wetland sample point 1—this point was inundated in December 2012 (11/07/12)

Photo 10: Upland sample point 5—point is located in area dominated by baltic rush and California blackberry (12/03/12)

SOURCE: ESA, 2012

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Figure B-5
Representative Photographs

Photo 11: Wetland sample point 6—point is within bulrush wetland with baltic rush, soft rush, and water parsley (12/03/12)

Photo 12: Impound Lake in vicinity of sample points 3 and 4 shows typical gradient from wetland to upland vegetation (10/25/12)

SOURCE: ESA, 2012

Figure B-6
Representative Photographs

Photo 13: Impound Lake with willow scrub and bulrush wetland (09/24/12)

Photo 14: Upland sample point 7—pit is 8 inches above lake level and dominated by water smartweed and California blackberry (12/03/12)

SOURCE: ESA, 2012

Figure B-7
Representative Photographs

Photo 15: Wetland sample point 9—pit is in wetland dominated by bulrush and water smartweed (12/03/12)

Photo 16: Fishing pier at South Lake with bulrush wetland and willow scrub (09/24/12)

SOURCE: ESA, 2012

Figure B-8
Representative Photographs

Photo 17: Wetland sample point 10—pit is in willow scrub wetland with water smartweed dominant in the understory (12/03/12)

SOURCE: ESA, 2012

Figure B-9
Representative Photographs

VISTA GRANDE DRAINAGE BASIN IMPROVEMENT PROJECT

Water Quality Assessment

Prepared for
City of Daly City

December 2015

for: JACOBS ASSOCIATES

VISTA GRANDE DRAINAGE BASIN IMPROVEMENT PROJECT

Water Quality Assessment

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EXECUTIVE SUMMARY

This section summarizes the Water Quality Assessment (WQA) prepared by the City of Daly City (Daly City) for Lake Merced and the Vista Grande Canal (Canal) related to the proposed Vista Grande Drainage Basin Improvement Project (project). The WQA, and associated supplemental 2011-2012 dry and wet season monitoring, were developed in cooperation with the San Francisco Public Utilities Commission (SFPUC) and the San Francisco Bay Regional Water Quality Control Board (RWQCB) to document existing hydrologic and water quality conditions and provide analysis of potential changes to those existing conditions as a result of project operations, consistent with the RWQCB's applicable regulatory processes. As discussed below and in this WQA, the project could result in an overall water quality improvement in lake water quality with proposed project operations. Daly City and the SFPUC are in coordination regarding the proposed design and operation of the project and management of the Lake under a range of potential Lake Merced water surface elevations (WSEs). Daly City, as the state Lead Agency under the California Environmental Quality Act (CEQA), and the National Park Service (NPS), as the federal Lead Agency under the National Environmental Policy Act (NEPA), will prepare a joint Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) for the project that will include an analysis of potential impacts to Lake Merced, including water quality. Based in part on this analysis, SFPUC will ultimately determine the appropriate WSE for operational purposes.

Daly City is proposing the project to address storm-related flooding that currently occurs in the Vista Grande Drainage Basin (Basin). The project would also provide the green infrastructure benefit of capturing existing Basin stormwater and authorized non-stormwater runoff that is currently conveyed to the Pacific Ocean, and beneficially using it to augment water levels in Lake Merced, which have declined compared to historic levels. The project would alleviate flooding potential and protect the existing ocean outlet from ongoing coastal erosion. Further, the project would reconnect a significant portion of the historic Lake Merced Watershed to the Lake, since the Vista Grande storm drain system drains the northwestern portion of Daly City and an unincorporated portion of San Mateo County – areas originally within the Lake Merced watershed.

The WQA includes an overview of the project purpose and need (Chapter 1), a summary of the project description with a focus on project operations (Chapter 2), the regulatory setting for both the project and for the project water quality assessment (Chapter 3), documentation of existing conditions in the Lake (Chapter 4) and in the Canal (Chapter 5) (including a summary of data collected specifically in support of this assessment), and detailed results and discussion of modeling conducted to assess the relevant potential project-related changes to existing conditions in Lake Merced (Chapter 6).

S.1 Watershed Background

Urban and historic agricultural development for more than a century has significantly reduced Lake Merced's original watershed and, as a result, the vast majority of surface runoff has been diverted away from the Lake as compared to historic hydrologic conditions. Most Basin surface runoff is currently diverted directly to the Pacific Ocean via the Vista Grande Canal and Tunnel. The existing Tunnel, with a capacity of 170 cubic feet per second (cfs), does not have adequate hydraulic capacity to convey peak Canal storm flows (500 cfs capacity). Flows in excess of the capacity of the Canal and the Tunnel have resulted in flooding in nearby low-lying residential areas and in overflows across John Muir Drive into Lake Merced, causing property damage, bank erosion, traffic nuisances, and public safety issues. The project would address local storm-related flooding issues by increasing the capacity of the Tunnel and would also provide regional watershed benefits by re-establishing the historic surface water connection between the Vista Grande Drainage Basin (Basin) and the Lake and managing water levels in Lake Merced.

S.2 Proposed Project Description

With implementation of the project, a portion of stormwater and authorized non-stormwater flows in the Canal would be diverted to the Lake. These flows would pass through a debris screening device and enter a diversion structure, which would enable all or only portions of the Canal flow to be directed through a proposed constructed treatment wetland and then to the Lake, be routed directly to the Lake from the Canal, or be allowed to continue through the Canal and Tunnel to the ocean outlet. A constructed treatment wetland would be developed along John Muir Drive to treat low-volume stormwater flows, year-round authorized non-storm flows, and recirculated water from the Lake in order to reduce levels of sediment, suspended solids, metals, microbiological constituents (bacteria and other organisms), and nutrients prior to release to Lake Merced. The relative contribution of water conveyed to the Lake through the constructed treatment wetland, as compared to direct diversions, would vary, but is expected to be approximately 45 to 60 percent once the Lake reaches the target mean WSE and flows from the Canal are diverted to maintain the selected WSE. As described further in the report, Daly City and SFPUC will develop diversion criteria and other operational protocols to determine when flows will be diverted so as to maximize beneficial reuse while attaining and maintaining water quality and the selected WSE.

S.3 Regulatory Setting

In collaboration with SFPUC and RWQCB staff, Daly City developed the "Proposed Regulatory Process for the Vista Grande Drainage Basin Improvement Project, Lake Merced Alternative" and submitted it to the RWQCB staff, and staff concurred (March 12 and May 9, 2013 letters, respectively). The intent of the Regulatory Process letter was to identify the steps and elements involved in moving the project forward in coordination with RWQCB requirements. Key elements are summarized below.

- Existing and proposed diversions of flows from the Vista Grande Canal to Lake Merced are covered under the existing Phase 1 Municipal Separate Stormwater System (MS4) National

Pollutant Discharge Elimination System (NPDES) permit, called the Municipal Regional Stormwater Permit (MRP), RWQCB Order No. R2-2009-0074. No additional NPDES permits are needed for operation of the project.

- Lake Merced currently does not meet the generally applicable Basin Plan Water Quality Objectives (WQOs) for dissolved oxygen (DO) and pH because the Basin Plan does not acknowledge the potential effects of diurnal and/or seasonal stratification in a lake environment nor of the effects of natural conditions, such as eutrophication, on ambient DO and pH. The DO and pH WQOs are also assumed to apply throughout the water column, at all locations within the Lake, and at all times, diurnally and seasonally. As a result, the U.S. Environmental Protection Agency (USEPA) in 2003 included Lake Merced on the Clean Water Act Section 303(d) list of impaired waterbodies for these constituents, notwithstanding the RWQCB's and State Water Board's recommendation not to include those listings.
- Daly City and SFPUC have agreed to develop a Lake Management Plan (LMP) as part of the project approach for maintenance and improvement of the existing and future water quality of Lake Merced.
- The RWQCB is pursuing a Basin Plan amendment to incorporate site-specific implementation provisions for the DO and pH WQOs to address Lake Merced's unique conditions.
- Once the LMP becomes effective and the Basin Plan site-specific DO and pH implementation provisions are fully approved and effective, the RWQCB could proceed with recommending to USEPA the de-listing of Lake Merced for DO and pH.

S.4 Monitoring Program Summary

Separate dry and wet season monitoring programs were developed in collaboration with RWQCB staff and implemented in 2011 and 2012. The monitoring program included collection of detailed seasonal, spatial (including at various depths), and temporal (hourly) DO and pH data to establish the baseline water quality of the proposed receiving waters (South Lake) relative to the 303(d) listings. Additionally, the monitoring data quantified dry and wet season Canal flows and established the baseline water quality within the Canal coincident with baseline water quality in the Lake. The intent of the water quality monitoring conducted within the Canal was to confirm that concentrations of key water quality constituents were generally in the ranges expected for urban stormwater and non-stormwater runoff and that diversions pursuant to the project were unlikely to have discernible impacts on the water quality or beneficial uses of the Lake. The findings and conclusions of the WQA were based on the water quality data collected during the dry and wet season of 2011-2012 as well as routine water quality data collected by the SFPUC in Lake Merced since 1997.

S.5 Water Quality Effects of Increasing Lake Depth

The project could result in an overall water quality improvement for key lake water quality constituents with proposed project operations. The analysis of the potential changes to existing Lake Merced water quality conditions resulting from project operations is based largely on best available spreadsheet-based modeling of the effects of increasing the mean depth of Lake Merced through use of stormflows and base flows from the Canal. The WQA considered how project operations may influence pH and DO levels in Lake Merced as well as other variables and constituents (e.g., algae, nutrients, water clarity) that control them. Future stratification and eutrophication conditions from project operations as well as potential changes to fish habitat were also assessed. Additionally, the numerous processes and variables within a Lake that can affect water quality, such as thermal and chemical stratification and nutrient dynamics, were assessed in the context of the proposed project against the baseline water quality data. These processes were analyzed and assessed to more fully understand the implications of the project on the overall ecology and health of the Lake.

Canal water quality generally had characteristics typical of urban stormwater and authorized non-stormwater flows for a broad range of constituents (such as nutrients, metals, and bacteria). Concentrations of these constituents were generally in the ranges expected for urban stormwater and non-stormwater runoff and Canal water is unlikely to have discernible water quality effects on the Lake, especially when considering the relative contribution of storm flows as compared to overall lake volume, the use of treatment wetlands, and the proposed operating model designed to ensure the protection of water quality. As part of the determination of potential water quality effects to Lake Merced, the consideration of Canal water quality results were considered within the context of proposed physical and operational project elements, as well as regulatory controls to urban runoff water quality, and hydrologic elements, such as the relative volume of Canal flows as compared to Lake volume. Hydrologic monitoring demonstrated that typical storm events in the Basin generate a volume equivalent to a fraction of 1 percent of the total Lake storage volume. The design hydrograph (i.e., peak storm event) for the project is a 25-year recurrence interval, 4-hour event generating a maximum peak flow of 1,070 cfs. Assuming 100 percent diversion of the design storm flow, the maximum volume of contribution from the Canal to Lake Merced during a single storm event would be approximately 190 acre-feet, representing a maximum of approximately 3 percent of the total volume of Lake Merced (5,625 acre-feet). Stormwater discharges may cause short-term increases in bacterial, metals, and nutrients concentrations in the receiving waters in the immediate vicinity of the diversion outlet but concentrations would likely rapidly equilibrate with the background levels in the Lake within several days following a diversion event. Further, the constructed treatment wetland is expected to reduce bacteria, metals, and nutrients concentrations in base flows and low-volume stormwater flows through settling, natural die-off, adsorption, solar irradiation, oxidation, competition, and predation such that it is unlikely that Lake concentrations would increase to a significant degree and result in substantial water quality effects.

The overall effect of the project, with the controls to ensure the protection of water quality in Lake Merced, would be an improvement in water quality that would be progressive with increases in depth. Model analyses were conducted to estimate the water quality changes that could occur from increasing Lake WSEs at the range of proposed depth increases using Canal water. The model analyses focused on two key variables that affect Lake health: mixing depth and nutrient availability. As the Lake depth increases, less frequent mixing of stratified layers in the deeper Lake would result in relatively less nutrients stirred up from the bottom and consequently less algae growth and eutrophication. The modeled range of depth increases produced estimated chlorophyll a reductions of up to 23 percent.

Nutrient effects were then modeled to assess how inputs of nutrients in storm and base flows could affect algal growth in Lake Merced for the filling period (when the lake level is increasing to the target WSE) and for the steady state period (when smaller annual contributions are made to maintain the target WSE range). Depending on the details of the design and operation of the treatment wetland, the proposed flows would likely result in minor increases or decreases in key nutrient concentrations in the Lake. The net effects on algal concentrations during the filling period would be an estimated increase of about 5 percent to an estimated decrease of up to 9 percent in the Lake chlorophyll concentration. For context, an increase in Lake algae of 32 percent is about that which would be analytically detectable from background conditions. After the Lake reaches the target WSE at the end of the filling period, it is likely there would be a decrease in algae of 6 to 10 percent, and a corresponding reduction in pH could occur. Thus, once the steady state WSE is reached, in conjunction with the treatment wetland, reduced annual average algal concentrations would be expected. Additionally, it is possible that the Lake eutrophication conditions would further improve over time as the reduced annual average algal concentrations result in reduced algal related organic matter loading to the sediments, reduced oxygen depletion in the bottom waters, and reduced internal loading of nutrients. However, some periods of anoxia would remain. Thus, the maximum increase in depth would not be a cure for the bottom water low DO episodes relating to naturally occurring seasonal stratification.

In addition to the water quality improvement resulting from lake level increases and use of the stormwater treatment wetland, the project includes intake and recirculation of lake water during dry weather periods to maintain the treatment wetlands. The intake of lake water from areas of concentrated surface algae would allow for direct removal of algae and associated substantial decreases in chlorophyll. The project also includes controlled overflows of lake water to the Vista Grande Tunnel, using a siphon to allow higher TDS and higher salinity bottom water to be displaced, increasing the benefit of flushing water out of the lake.

The fishery-related ecosystem of Lake Merced can be summarized as a moderately enriched Lake that supports self-sustaining populations of native and non-native fish species. The results of the assessment of potential changes in the temperature, DO, and pH profiles of the Lake were reviewed in light of known habitat requirements of the Lake Merced fish species. Temperature, DO, and pH profiles are not expected to change significantly with increased water surface elevations. Therefore, no significant changes to habitat conditions relating to water quality are anticipated for warmwater or coldwater fish.

In summary, the project would capture and beneficially reuse existing Basin stormwater and authorized non-stormwater runoff to augment water levels in Lake Merced, which have declined compared to historic levels, without adversely affecting the beneficial uses Lake Merced is designated to support. The proposed project would also alleviate local flooding potential and protect the existing ocean outlet from ongoing coastal erosion. Further, the project would reconnect a significant portion of the historic Lake Merced Watershed to the Lake. Capturing and beneficially reusing Canal flows could result in an overall water quality improvement in lake water quality with proposed project operations and treatment wetlands. The improvement in water quality would likely be progressive with increases in depth and, following the filling period and in conjunction with the treatment wetlands, reduced annual average algal concentrations would be expected which in turn would improve Lake eutrophication conditions.

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CHAPTER 1
Introduction

This report constitutes the Water Quality Assessment (WQA) for Lake Merced and the Vista Grande Canal (Canal) that the City of Daly City (Daly City) prepared in part to establish baseline water quality conditions for the proposed Vista Grande Drainage Basin Improvement Project (project). This report also provides a prospective assessment of the potential project effects on Lake Merced water quality within the San Francisco Bay Regional Water Quality Control Board's (RWQCB) regulatory processes. The findings and conclusions of the WQA are based on water quality data acquired by others over the past several years as well as water quality data obtained by Daly City during the dry and wet seasons of 2011-2012. The data collection approach was agreed upon by the RWQCB as part of the System Understanding and Assessment Strategy (**Appendix A**) for the project, and is consistent with the Final 2011 Dry Season Monitoring Plan and Final 2011-2012 Wet Season Monitoring Plan (**Appendix B**).

The System Understanding and Assessment Strategy served as the basis for the "Proposed Regulatory Process for the Vista Grande Drainage Basin Improvement Project, Merced Alternative" (Regulatory Process letter) developed by Daly City for the project (March 12, 2013 letter), with concurrence from the RWQCB staff (May 9, 2013 letter). As outlined in Chapter 3, Regulatory Setting, the information provided in this WQA will be used to inform the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) processes, and regulatory compliance, as applicable.

The water quality sampling program and assessment was prepared as a collaboration between ESA, Jacobs Associates, EOA, Inc., and Dr. Alex Horne (see Chapter 8, List of Preparers), with input from Daly City, the San Francisco Public Utilities Commission (SFPUC), and RWQCB staff.

Chapter 1 provides an overview of the project, including the need for the project, and summarizes the water quality assessment conducted in support of the project.

1.1 Project Need and Overview

Daly City is proposing the project to address storm-related flooding that currently occurs in the Vista Grande Drainage Basin (Basin). The project would also provide the green infrastructure benefit of capturing existing Basin stormwater and authorized non-stormwater runoff that is currently conveyed to the Pacific Ocean, and beneficially using it to augment water levels in Lake Merced, which have declined compared to historic levels. The project would alleviate flooding potential and protect the existing ocean outlet from ongoing coastal erosion. Further, the project would reconnect a significant portion of the historic Lake Merced Watershed to the Lake, since the Vista Grande storm drain system drains the northwestern portion of Daly City and an unincorporated portion of San Mateo County – areas originally within the Lake Merced watershed.

Lake Merced is made up of four individual but connected lakes (East, North, South, and Impound Lakes) and is owned by the City and County of San Francisco (San Francisco). The SFPUC maintains the Lake as a non-potable emergency water supply for San Francisco and is a responsible agency for this project. The Canal and the Vista Grande Tunnel (Tunnel) were built in the 1890s to direct stormwater away from urban development to an outlet at the Pacific Ocean, below what is now Fort Funston, which is part of the National Park Service's (NPS) Golden Gate National Recreation Area (GGNRA). The existing Canal and Tunnel do not have adequate hydraulic capacity to convey peak storm flows, which periodically cause flooding in adjacent low-lying residential areas and overtopping along John Muir Drive. A portion of the western end of the Tunnel, once enclosed within the cliffs at Fort Funston, has become exposed due to the ongoing erosion of the cliff face and has been capped with a concrete outlet structure.

The project would involve partial replacement of the existing Canal, replacement of the existing Tunnel, and replacement of the existing ocean outlet structure. The location of these existing components is shown in **Figure 1-1**. Additionally, operational components of the project would include management of water elevations in Lake Merced by routing some screened wet-weather storm flows from the Canal to Lake Merced, and year-round authorized non-storm flows to the constructed treatment wetland which would subsequently discharge flows to Lake Merced. The project also includes a Lake Management Plan that would include adaptable best management practices.

The proposed project has been developed in cooperation with the SFPUC and the RWQCB, which regulates water quality in the region. Daly City and SFPUC are in coordination regarding the proposed design and operation of the proposed project and management of the Lake under a range of potential Lake Merced water surface elevations (WSEs). Daly City, as the Lead Agency under CEQA, and the NPS, as the Lead Agency under NEPA, will prepare a joint Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) for the project that will include an analysis of potential impacts to Lake Merced, including water quality. The project is described further in Chapter 2, Project Description Overview.

SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 1-1
Project Location

1.2 Document Background and Organization

The WQA was conducted to document existing conditions in Lake Merced and to provide an analysis of potential changes to existing water quality conditions as a result of project operations. This WQA provides an overview of historical monitoring data collected by the SFPUC, as well as additional monitoring and sampling data collected at South Lake and the Canal as part of the assessment effort by Daly City.

This Water Quality Assessment includes:

- **Chapter 1, Introduction** – This chapter provides an overview of the project, and summarizes the water quality assessment conducted for the project.
- **Chapter 2, Project Description Overview** – This chapter summarizes the proposed project, primarily focusing on project operation and potential scenarios for conveyance of stormwater from the Canal to Lake Merced.
- **Chapter 3, Regulatory Setting** – This chapter summarizes the San Francisco Bay Regional Water Quality Control Board Basin Plan beneficial uses for Lake Merced, water quality objectives, Clean Water Act Section 303(d) impairment listing of the Lake, and stormwater regulation under the Municipal Regional Stormwater Permit and under the State Water Board Phase II General Stormwater Permit.
- **Chapter 4, Lake Merced Existing Conditions** – This chapter summarizes the climate and precipitation, hydrology, existing water quality, processes affecting Lake water quality, and existing biological resources.
- **Chapter 5, Vista Grande Canal Existing Conditions** – This chapter summarizes the hydrology, water quality, and processes affecting Canal water quality.
- **Chapter 6, Water Quality Assessment – Lake Level and Water Quality Modeling Results** – This chapter describes the results of modeling conducted to assess the potential project-related changes to existing conditions; in particular on Lake Merced dissolved oxygen (DO), pH, and lake processes such as stratification and phytoplankton growth primarily associated with those constituents.
- **Chapter 7, References** – This chapter lists the reference sources cited throughout this report.
- **Chapter 8, List of Preparers** – This chapter lists the contributors to this report.

CHAPTER 2
Project Description Overview

This chapter includes an overview of the components that would be constructed and operated under the proposed project. Because the focus of this report is on existing Lake Merced water quality and expected water quality conditions under project operations, the proposed project facilities are briefly described in this chapter, followed by a description of potential operational strategies for input of stormwater and authorized non-storm flows into Lake Merced, including the range of operational Lake levels, stormwater input operating conditions, and rate of input into the Lake that could occur under the project.

The Basin (the watershed that drains into the Canal), is located in Daly City and in unincorporated Broadmoor Village in northwestern San Mateo County. The watershed is currently drained through the Canal and Tunnel, which are located in San Francisco, adjacent to John Muir Drive and the southwestern shoreline of Lake Merced. The tunnel outlet is located at the Pacific Ocean at Fort Funston.

The existing Canal is a 3,600-foot-long, man-made brick-lined trapezoidal channel with a flow capacity of approximately 500 cubic feet per second (cfs). The Project would replace the upstream portion of the Canal with a collection box, box culvert, debris screening device, and diversion structure. A constructed treatment wetland would be developed in an area between John Muir Drive and the southern edge of the Canal to handle low flows (dry and wet) year-round. From the diversion structure, a box culvert would be developed under John Muir Drive and a screened outlet structure constructed at the edge of Impound Lake.

The project would consist of the following structural components (existing location shown in **Figure 2-1**):

- Improvements within the Vista Grande Basin storm drain system upstream of the Vista Grande Canal;
- Partial replacement of the existing Vista Grande Canal to incorporate a gross solid screening device, a constructed treatment wetland, and diversion and discharge structures to route some stormwater (and authorized non-storm water) flows from the Vista Grande Canal to Lake Merced and to allow lake water to be used for summer treatment wetland maintenance;
- Modification of the existing lake overflow structure to include an adjustable weir and siphon that allows water from the lake to flow into the Canal and Tunnel;

SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 2-1
Existing Vista Grande Structures

- Modification of the existing effluent gravity pipeline so that it may be used year round to convey treated effluent from the nearby North San Mateo County Sanitation District Wastewater Treatment Plant (WWTP) to the existing outlet and diffuser by gravity, and abandoning the force main pipeline;
- Replacement of the existing Vista Grande Tunnel to expand its hydraulic capacity and extend its operating lifetime and replacement of the Lake Merced Portal to the tunnel; and
- Replacement of the existing ocean outlet structure and a portion of the existing submarine outfall pipeline that crosses the beach at Fort Funston.

These components and locations are shown in **Figures 2-2a** and **2-2b**.

Operational components of the project, further described below, would include management of WSEs in Lake Merced and a Lake Management Plan that would address in an adaptive manner best management practices for the control of water quality and includes a long-term monitoring plan that would address the types of water quality effects described in Chapter 6, Water Quality Assessment – Lake Level and Water Quality Modeling Results.[1] Additionally, the Lake Management Plan includes details of upstream improvements in the basin and additional actions, the implementation of which may be triggered during post-project monitoring.

2.1 Project Operation and Lake Level Management Overview

Stormwater and authorized non-stormwater flows would flow by gravity through a box culvert located below the proposed constructed treatment wetland for a distance of approximately 1,500 feet. Here the flow would enter a diversion structure where it could be pumped to the treatment wetland, or either directed to Lake Merced or allowed to continue through the canal and tunnel to the ocean outlet. Variable control would be available at the diversion structure gates so that all or only portions of the flow may be directed in either direction.

The collection box, box culvert, gross solids screening device, and diversion structure would be sized to accommodate peak flows generated by the 4-hour, 25-year design storm, which is approximately 1070 cfs. The box culvert under John Muir Drive would also be designed to accommodate the full capacity of 1070 cfs; however, since a portion of the total flow could be directed through the canal and tunnel, only approximately 570 cfs capacity is needed to accommodate peak flows generated by the design storm. The segment of the canal between the diversion structure and the tunnel portal would remain unimproved, with a capacity of approximately 500 cfs. The improved tunnel would be designed with a capacity of at least 500 cfs.

1 The Draft Lake Merced Management Plan is being developed as a separate report and will be provided to the RWQCB for input prior to incorporation of the plan into the project description and EIR/EIS.

SOURCE: Jacobs Associates, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 2a

Proposed Project Components (Canal)

SOURCE:

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 2b

Proposed Project Components (Tunnel)

2-23-0862

Exhibit 6

After passing through the solids screening device, year-round low flow stormwater and authorized non-storm flows would be pumped at rates of up to approximately 400 gallons per minute (gpm) to the start of one of the surface treatment wetland cells. Water would flow by gravity to the terminus of the constructed treatment wetland, where it would typically drop into a box culvert below and continue to flow into Lake Merced. Treated water would also have the capability of dropping into the diversion structure and continuing through the Canal and Tunnel in order to bypass Lake Merced if requested by the SFPUC, such as during maintenance of the constructed treatment wetland or other related components.

The gross solids screening device would be emptied of collected debris approximately twice per year, once after the initial storm flow of the wet season and once at the end of the wet season. Post-project monitoring would determine whether more frequent cleaning would be required. Vacuum trucks would access the device via a new 15-foot-wide access road on the western side of John Muir Drive. It is anticipated that as much as 100 cubic yards of debris could be removed at each cleaning.

In order to maintain lake levels within target WSEs and to ensure protection of water quality within Lake Merced, the proposed operating model includes provisions for routing stormwater to Lake Merced. The initial storm event of the winter season and other storm events with long antecedent dry periods would flow through the Canal to the Tunnel and then to the ocean outlet. Stormwater would be routed to Lake Merced dependent on stormwater flow rate, Lake Merced WSE, and other diversion criteria, including rainfall frequency, predicted rainfall duration and magnitude, canal flow rates, and other factors. More detailed diversion criteria would be developed further during design of the diversion facilities, and further refined following the first wet season of operation. However, the principal diversion routing options are:

1. **Summer and Winter Low-Flow Routing, Lake Merced below target WSE.** Screened dry weather flows (authorized non-stormwater) and low-volume stormwater flows would be routed through the constructed treatment wetland, after which the treated water would drain into the Lake Merced Outlet to Impound Lake. These flows would help to maintain overall lake level and sustain the proposed treatment wetland throughout the year. There would be no flow through the tunnel or beach discharge.

2. **Summer and Winter Low-Flow Routing, Lake Merced at target WSE.** Screened dry weather flows (authorized non-stormwater) and low stormwater flows would be routed through the constructed treatment wetland after which the treated water would drain into the Lake Merced Outlet to Impound Lake. These flows would help to maintain overall lake level and sustain the proposed treatment wetland throughout the year. Inflows into Impound Lake would increase the WSE above the Lake Merced Overflow elevation, resulting in outflows from South Lake to the Tunnel via the Lake Merced Overflow. Overflows would be conveyed via the Tunnel to the ocean outlet.

3. **Winter Storm Routing, Lake Merced below target WSE.** Screened initial stormwater flows would be routed through the canal and discharged via the Tunnel and ocean outlet. After initial storm event, if screened storm flows meet diversion criteria, flows exceeding the capacity of the constructed treatment wetland would be routed directly to Impound Lake, and there may be no flow through the tunnel or beach discharge.

4. **Winter Storm Routing, Lake Merced at target WSE.** Screened initial stormwater flows would be routed through the canal and discharged via the Tunnel and ocean outlet. After initial storm event, if screened storm flows meet diversion criteria, flows exceeding the capacity of the constructed treatment wetland would be routed directly to Impound Lake. Inflows into Impound Lake would increase the WSE above the Lake Merced Overflow weir elevation, resulting in outflows from South Lake to the Tunnel and ocean outlet via the Lake Merced Overflow.

5. **Winter Storm Exceeding 25-year, 4-hour criteria, Lake Merced at target WSE.** Screened initial stormwater flows would be routed through the canal and discharged via the Tunnel and ocean outlet. After initial storm event, if screened storm flows meet diversion criteria, flows exceeding the capacity of the constructed treatment wetland would be routed directly to Impound Lake. In addition, if storm water flows from the Vista Grande watershed exceed the combined capacity of Lake Merced and the Vista Grande Canal and Tunnel, canal flows could overtop the canal and flow across John Muir Drive to Lake Merced. Flows would cross the existing hardscape areas between John Muir Drive and South Lake and discharge into Lake Merced via existing riprap Canal overflow discharge structures along the shoreline (Figure 2-2a). Inflows into either Impound Lake or South Lake would result in overflows back to the tunnel as capacity is available and would be discharged via the ocean outlet. This option would temporarily raise lake levels above the target WSE, providing short-term storage during major storm events to reduce flooding in the Basin.

2.2 Proposed Constructed Treatment Wetland and Lake Outlet

The project would divert some stormwater and authorized non-stormwater flows to Lake Merced to aid the SFPUC in managing Lake Merced water levels. The water level of Lake Merced has fluctuated historically from Elevation (El.) 13 feet (San Francisco City Datum)[2] in the 1940s (City Datum is 11.37 feet higher than the North American Vertical Datum 1988) to a low of El. -3.2 feet in 1993. Since then, the WSE of Lake Merced has risen due to increases in average rainfall and water additions by the SFPUC (SFPUC, 2011b). From 2006 to 2010, the WSE ranged from El. 4.8 feet to El. 6.9 feet with an average of approximately El. 5.8 feet (City Datum). SFPUC has identified a goal of improving water levels in the lake to serve beneficial uses and provide a reliable emergency water supply for firefighting or sanitation purposes, and subject to a boil water order, if no other sources of water are available (SFPUC, 2011a). As discussed in Chapter 1, Introduction, the Memorandum of Understanding (MOU) developed between Daly City and SFPUC includes consideration of a range of WSE scenarios for Lake Merced between 5.5 and 9.5 feet City Datum. The range of potential WSE scenarios considered initially for the purposes of analysis includes mean WSEs of 6.5 to 8.5 feet, with a maximum high WSE of 9.5 feet. However, the actual proposed operational WSE range would be determined by the

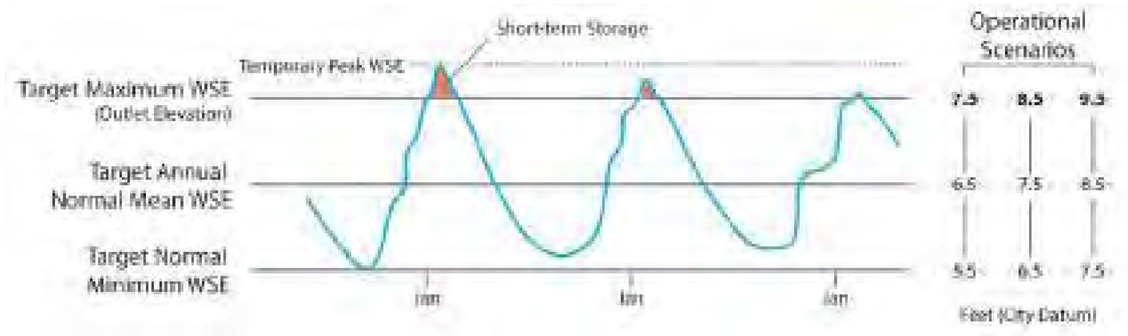
[2] Elevations in San Francisco are commonly referenced to three vertical datums, including the North American Vertical Datum of 1988 (NAVD 88), the National Geodetic Vertical Datum of 1929 (NGVD 29), and the San Francisco City Datum (City Datum). NAVD 88 was established in 1991 and is the most up-to-date and accurate datum. NGVD 29 was used by surveyors and engineers for most of the 20th century and is 2.76 feet lower than NAVD 88. The San Francisco City Datum was set at 6.7 feet above the former high water mark and is 11.38 feet higher than NAVD 88 and 8.62 feet higher than NGVD 29. Lake Merced elevations have commonly been referenced to the City Datum.

SFPUC, following completion of the CEQA/NEPA review process. The EIR/EIS will evaluate the complete range of potential operational WSEs.

A constructed treatment wetland would be developed along John Muir Drive to treat year-round low flows from the watershed in order to reduce sediment, suspended solids, metals, microbiological constituents (bacteria and other organisms), and nutrients. Low volume stormwater flows, authorized non-storm flows, and recirculated lake water would be treated prior to release to Lake Merced. The wetland would consist of two cells (A and B), with areas totaling approximately 2.75 acres. The project would include the highest level of treatment possible within the acreage available for development of treatment wetlands. A portion of Wetland Cell A would overlie the box culvert. Wetland Cell B would be located between the existing Canal and John Muir Drive. The wetland would treat year-round low flows from the watershed (also referred to as base flows), which can consist of authorized non-stormwater flows such as residential irrigation runoff. Low flows would drain to the wetland pump station from the flow diversion structure via a 12-inch drain where two motorized pumps would pump water to one of the wetland cells. Water would then flow by gravity through the wetland at a rate of approximately 1.4 cfs. The wetland cells would be planted with emergent reeds such as cattails or bulrush that would provide water quality improvement by intercepting and settling out suspended particulates and providing attachment surfaces for beneficial bacteria. After passing through the wetland, the treated water would flow by gravity through the diversion structure to the Lake Merced Outlet. During periods of very low or no flow, a recirculating pump would draw water from Lake Merced and replenish the wetland. Water would be withdrawn from targeted locations within the Lake through a section of pipe installed within the lake. Stormwater and authorized non-stormwater flows exceeding the treatment wetland capacity (1.4 cfs) would pass through a solids screening device and then, depending on operational protocols, would either be routed to Lake Merced or be allowed to continue through the Canal and Tunnel to the ocean outlet.

Flows that are directed into Lake Merced would be conveyed via a box culvert constructed under John Muir Drive to an outlet at the northwestern portion of the Impound Lake shoreline. The water would flow through the submerged outlet structure into Impound Lake, which is hydrologically connected to South Lake. The specific location of the outlet structure will be determined based on further engineering and environmental review. If alternative outlet locations are developed as part of the project, such as in South Lake, these alternatives will be assessed in detail in the EIR/EIS. For the purpose of the Chapter 6 analysis, it was assumed based on discussions with Daly City during design of the monitoring plans that the outlet structure would be located in South Lake.

Chapter 6 focuses on three potential operational annual normal mean WSE scenarios: 6.5, 7.5, and 8.5 feet, as defined in the MOU between Daly City and the SFPUC. As described in Section 4.2, Lake Merced Hydrology, the annual mean WSE has been approximately 6 feet City Datum in recent years. Accordingly, the operational WSEs considered in this assessment represent an increase over the recent annual mean by 0.5, 1.5, and 2.5 feet. After winter rains taper off, about 1.5 feet of water is lost each year, primarily due to evaporation. Thus, for each scenario there is a corresponding target normal minimum WSE. The term normal is used to refer to normal and wet year conditions. Under dry year and multiple dry year conditions, it is assumed that the WSE of Lake Merced would fall below the target normal range. During a storm event, the Lake's WSE may rise above the target maximum WSE, as the flow of stormwater being diverted into the Lake exceeds the capacity of the overflow outlet, thus providing short-term water storage for flood events (see **Figure 2-3**).



SOURCE: ESA and Jacobs Associates

Vista Grande Drainage Basin Improvement Project – 207036.01

Figure 2-3
Preliminary Lake Level Operational Scenarios

2.3 Stormwater Diversion Scenarios

Table 2-1 presents baseline sources of inflow and outflow to Lake Merced during dry (1976), wet (1965), and average (1953 to 2008, exclusive) years. As shown, inflow from stormwater and precipitation and outflow from evaporation and transpiration vary across the years. Thus, for this preliminary analysis, inflow and outflow from groundwater are assumed to be constant at 69 acre-feet and 171 acre-feet, respectively. This information was used to produce the estimates of Lake filling scenarios below.

TABLE 2-1
LAKE MERCED SOURCES OF INFLOW AND OUTFLOW

Year Type	Inflow (acre-feet)			Outflow (acre-feet)			Balance
	Stormwater	Precipitation	Groundwater	Groundwater	Evaporation	Transpiration	
Dry (1976)	45	238	69	-171	-755	-134	-708
Wet (1965)	1,183	514	69	-171	-562	-128	905
Average (1953 – 2008)	218	499	69	-171	-635	-135	-155

SOURCE: ESA

Table 2-2 presents the estimated maximum volume of Lake Merced (all four Lakes) under the three operational scenarios. The maximum Lake volume is projected to range from 6,074 acre-feet under a target maximum WSE of 7.5 feet to 6,685 acre-feet under a target maximum WSE of 9.5 feet. The maximum change in Lake volume under each scenario was conservatively calculated by comparing projected Lake volumes under each operational scenario to the average baseline annual low water surface elevation. Lake volume could increase by as much as 1,265 acre-feet under a target maximum WSE of 9.5 feet when compared to the average annual low WSE of 5.3 feet.

TABLE 2-2
LAKE VOLUMES UNDER OPERATIONAL SCENARIOS WITH MAXIMUM CHANGE IN VOLUME

Water Surface Elevation (feet, City Datum)	Volume (acre-feet)	Maximum Change in Volume (acre-feet)
Average Annual Low (5.3)[a]	5,420	N/A
7.5	6,074	655
8.5	6,378	958
9.5	6,685	1,265

NOTE:
a Based on SFPUC WSE data from 2006 to 2011. The average annual low water surface elevation was chosen as the baseline in order to provide the maximum change in volume for use in the water quality analysis.

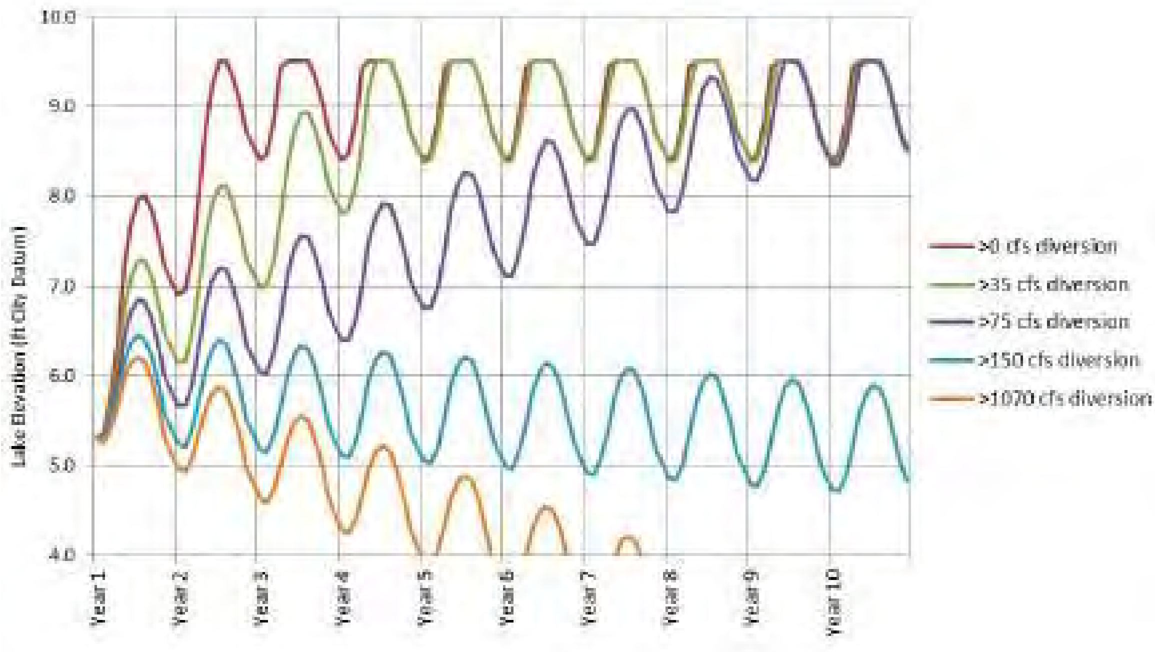
SOURCE: ESA, 2012

To estimate the potential contribution of stormwater flows diverted to Lake Merced, five diversion thresholds were analyzed. The diversion thresholds are structured such that all flows over a certain flow threshold would be diverted into Lake Merced. The thresholds are: > 0 cfs (i.e., all flows would be diverted to the Lake), > 35 cfs (i.e., flows greater than 35 cfs would be diverted to the Lake), > 75 cfs, > 150 cfs, and > 1070 cfs. The maximum predicted runoff reaching the Canal is approximately 1070 cfs,[3] so this threshold would not divert any stormwater to Lake Merced. These diversion thresholds have been developed to analyze a range of potential diversions. Specific operational criteria for stormwater diversions would be developed as part of the Lake Management Plan that would be included as part of the project and is subject to the completion of CEQA/NEPA environmental review and permitting processes (as described above).

The amount of time required to fill Lake Merced to the target WSEs included in this assessment is dependent upon the diversion thresholds. The lower non-zero diversion thresholds (i.e., > 35 and > 75 cfs) require multiple seasons to reach target WSE, during which time a large volume of water is lost to evaporation and transpiration (see Table 2-1, above). Accordingly, the base flows running through the constructed treatment wetland constitute a greater percentage of the Lake Merced contributions than does stormwater compared to the > 0 cfs threshold. Due to evaporation and transpiration, the highest diversion thresholds (i.e., > 150 and > 1070 cfs) would never achieve the target WSE included in this assessment.

Figure 2-4 illustrates the annual average contribution patterns under the five diversion thresholds for the 9.5-foot maximum WSE operational target. Because Figure 2-4 is based on the average year, it does not account for annual variability (see Table 2-1). The 9.5-foot target maximum WSE could be reached in a minimum of approximately 1.5 years under the > 0 cfs diversion threshold, 3.5 years under the > 35 cfs threshold, and 8.5 years under the > 75 cfs threshold. As described above and shown in the chart, the 9.5-foot target maximum WSE would not be achieved under the > 150 cfs and > 1070 cfs diversion thresholds. The Lake filling scenarios for the 7.5- and 8.5-foot target maximum WSEs are provided in **Appendix C**.

3 Maximum predicted runoff based on a design storm event with a 4-hour duration and a 25-year recurrence interval.



SOURCE: ESA

Vista Grande Drainage Basin Improvement Project – 207036.01

Figure 2-4
Lake Filling Scenarios, 9.5-Foot Target Maximum Water Surface Elevation

The time to reach target elevation and required filling period contributions under the different diversion thresholds are summarized in **Table 2-3**. The inflows shown in Figure 2-4 are based on the average water year (1953 to 2008 data) and provide a comparative estimate only. Under the average year assumptions, the > 150 cfs and > 1070 cfs diversion thresholds would not provide an adequate volume of water to offset the Lake outflows and meet the target WSE. Therefore, these two thresholds are not considered viable and are excluded from subsequent evaluation. As shown in Table 2-3, as the filling period is extended, the base flow contribution via the constructed treatment wetland to Lake level management is increased in relation to the contribution of stormwater, which would not pass through the treatment wetland. Chapter 6 uses the > 35 cfs threshold for modeling estimated effects to Lake water quality from the project (see Table 6-4); however, the > 75 cfs threshold may result in a greater proportion of treated base flows entering the Lake compared to untreated stormwater, but would take longer to fill the Lake to target WSE.

Once the Lake is raised to the target WSE, smaller annual contributions of flow from the Canal would be required to maintain the Lake within the target WSE range. **Table 2-4** lists the total annual volume of water contributions required from the Canal via the constructed treatment wetland and directly from the Canal to maintain the desired target WSE. Because the surface area of the Lake changes only slightly in the 6.5 to 8.5 foot WSE range, the maintenance contributions would be approximately the same for all operational scenarios (6.5, 7.5, and 8.5 foot target annual normal mean WSE). Contributions from the treatment wetland and the Canal, ranging from 403 acre-feet per year (> 75 cfs threshold) to 474 acre-feet per year (> 0 cfs threshold), in addition to smaller contributions from precipitation and groundwater inflow, would maintain the Lake level. The relative contribution conveyed through the constructed treatment wetland varies according to the stormwater diversion threshold, but is substantial (45 to 60 percent).

TABLE 2-3
FILLING PERIOD CONTRIBUTIONS

Flow Diversion Threshold[a] (cfs)	Time to Reach Target Elevation (months)[b]	Total Filling Period Contributions (acre-feet)			Annual Filling Period Contributions (acre-feet/year)		
		Canal via Wetland	Direct from Canal	Total	Canal via Wetland[c]	Direct from Canal	Total
7.5-foot maximum water surface elevation							
> 0	6	146	529	675	146	529	675
> 35	17	404	629	1,033	285	444	729
> 75	31	725	611	1,336	281	236	517
8.5-foot maximum water surface elevation							
> 0	17	404	1,033	1,437	285	729	1,014
> 35	30	699	1,017	1,716	280	407	687
> 75	67	1,554	1,225	2,779	278	219	497
9.5-foot maximum water surface elevation							
> 0	19	422	1,128	1,550	267	712	979
> 35	42	949	1,362	2,311	271	389	660
> 75	102	2,332	1,828	4,160	274	215	489

NOTES:
[a] All flows greater than the flow diversion threshold would be diverted into Lake Merced.
[b] Filling period based on average water year.
[c] The annualized contribution of the wetland varies slightly due to summer/winter variance in Vista Grande Canal base flows.

SOURCE: ESA

TABLE 2-4
ANNUAL MAINTENANCE CONTRIBUTIONS REQUIRED
FOR ALL TARGET WATER SURFACE ELEVATIONS

Flow Diversion Threshold (cfs)	Maintenance Contributions (acre-feet/year)[a]				
	Wetland	Canal	Wetland + Canal	Precipitation and Groundwater Inflow	Grand Total
> 0	216	259	474	87	561
> 35	230	211	441	120	561
> 75	244	159	403	158	561

NOTES:
[a] Based on average water year.

SOURCE: ESA

CHAPTER 3
Regulatory Setting

This section describes the beneficial uses that Lake Merced is designated to support, the key water quality objectives applicable to those uses, the history of the U.S. Environmental Protection Agency (USEPA) placing the Lake on the Clean Water Act Section 303(d) list as being impaired for elevated pH and low DO, and the similar but separate regulation of stormwater from the Daly City Vista Grande Watershed versus the SFPUC Lake Merced Watershed. Additionally, this section briefly summarizes the regulatory process that has been developed by Daly City, the SFPUC, and the RWQCB to address those 303(d) listings.

3.1 Beneficial Uses

The San Francisco Bay RWQCB Water Quality Control Plan (Basin Plan) designates Lake Merced as supporting the following beneficial uses:

- Cold Freshwater Habitat (COLD)
- Warm Freshwater Habitat (WARM)
- Fish Spawning (SPWN)
- Wildlife Habitat (WILD)
- Body-contact Recreation (REC1)
- Noncontact Water Recreation (REC2)
- Municipal And Domestic Supply (MUN)

Of the above designated uses, the uses that are most directly sensitive to the degree of eutrophication and stratification and associated pH and particularly DO levels within Lake Merced are those related to habitat quality for aquatic organisms; specifically, COLD, WARM, SPWN, and WILD. It should be noted that under stratified conditions, the respective uses may exist to differing degrees depending on the relative temperature, DO, and pH in the separated upper and lower portions of the Lake. REC1 and REC2 uses could also be affected to the extent that if algal growths were to increase to nuisance proportions it could interfere with recreational activities or adversely affect the aesthetic quality of Lake Merced. While the Basin Plan lists REC-1 (including full body-contact recreation) as a beneficial use of Lake Merced, swimming and wading in the Lake are not allowed by San Francisco since the Lake is also designated as a potential MUN source. As described in Chapter 1, SFPUC maintains Lake Merced as a non-potable emergency water supply for San Francisco to be used for firefighting or sanitation purposes, and subject to a boil water order, if no other sources of water are available (SFPUC, 2011a). Given these restrictions, this assessment of potential effects from addition of stormwater from the Canal to Lake Merced on the REC-1 beneficial use includes consideration of actual recreational uses of the Lake under baseline conditions.

3.2 Water Quality Objectives

The Basin Plan contains narrative and numeric water quality objectives (WQOs) that apply to most waters in the region and are intended, in part, to ensure that beneficial uses are protected. The current WQOs for biostimulatory substances (i.e., nutrients), DO, and pH are cited below from the Basin Plan; however, the RWQCB has confirmed that future regulatory modifications to the implementation plans for the DO and pH WQOs for Lake Merced are expected. While it is recognized that other WQOs exist for additional water quality constituents (pathogens, metals, etc.), the objectives presented below are those most relevant for review of overall Lake health.

Biostimulatory Substances. Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses. Changes in chlorophyll a and associated phytoplankton communities follow complex dynamics that are sometimes associated with a discharge of biostimulatory substances. Irregular and extreme levels of chlorophyll a or phytoplankton blooms may indicate exceedance of this objective and require investigation.

Dissolved Oxygen. For nontidal waters, the following objectives shall apply:

Waters designated as:

Cold water habitat (COLD)	7.0 milligrams per liter (mg/L) minimum
Warm water habitat (WARM)	5.0 mg/L minimum

The median DO concentration for any three consecutive months shall not be less than 80 percent of the DO content at saturation.

DO is a general index of the state of the health of receiving waters. Although minimum concentrations of 5 mg/L and 7 mg/L are frequently used as objectives to protect fish life, higher concentrations are generally desirable to protect sensitive aquatic forms. In areas unaffected by waste discharges, a level of about 85 percent of oxygen saturation exists. A three-month median objective of 80 percent of oxygen saturation allows for some degradation from this level, but still requires a consistently high oxygen content in the receiving water.

pH. The pH shall not be depressed below 6.5 nor raised above 8.5. This encompasses the pH range usually found in waters within the basin. Controllable water quality factors shall not cause changes greater than 0.5 units in normal ambient pH levels. (RWQCB, 2010)

Note that, as discussed in Section 3.4, the Basin Plan does not generally contain implementation provision language about how these WQO, particularly DO and pH, should be applied in different types of waterbodies (e.g., shallow versus deep waters).

3.3 Section 303(d) Listing

Under Section 303(d) of the Clean Water Act, states are required to develop a list of impaired waters, defined as water bodies that do not meet state water quality standards, every two years. Water quality standards include designated beneficial uses and WQOs (40 CFR 131.3(i)).

On November 28, 2001, during the 2002 303(d) listing process, Lake Merced was included on the RWQCB's "Preliminary List of Waterbodies and Pollutants" for "Low Dissolved Oxygen/Organic Enrichment." This was in Table 5 in the Board item approving transmittal of the 2002 303(d) list to the State Water Board. The accompanying staff report (p. 35) stated that:

> *Regional Board staff recommends that DO and pH be monitored systematically by a public agency such as the SFWD, the San Francisco Public Utilities Commission, or other stakeholder. This monitoring should be conducted at the same sites as the SFWD program plus additional sites within the different portions of the lake, and more frequently than before, continuously where resources allow, to assess whether the lake is truly impaired due to lack of DO or elevated pH. In the next listing cycle the Regional Board will re-evaluate DO and pH information, including the 1997-2000 data, and either accept or reject an impairment determination for DO and pH.*

On February 28, 2003 the State Water Resources Control Board (SWRCB) transmitted the State's 2002 303(d) list to USEPA. The SWRCB included Lake Merced on the "Monitoring List" for "Low Dissolved Oxygen." This did not require development of a Total Maximum Daily Load (TMDL). Waters were placed on the Monitoring List where "*minimal, contradictory or anecdotal information suggests standards are not met but the available data or information is inadequate to draw a conclusion*."

On June 5, 2003 the USEPA partially approved and partially disapproved California's 2002 Section 303(d) list. USEPA added Lake Merced to the 303(d) list under Category 5 (TMDL required) for DO and pH. As its rationale the USEPA stated in part that:

> *The San Francisco Bay Basin Plan includes numeric standards for dissolved oxygen and pH that are applicable to this water (San Francisco Bay RWQCB, 1995, p. 3-3). EPA's analysis of available data in the State's record found that 46-83% of available samples exceed the existing numeric water quality standards for DO and pH in Lake Merced, depending upon the monitoring station (n=14). The State has not provided a sound rationale for concluding that the water quality standards for pH and DO are not exceeded. The stated rationale that the available data may not be representative is unpersuasive.*
>
> *Data were collected at several locations over a recent multi-year time frame. The rationale that samples taken at depth should not be considered and that analysis only of surface samples demonstrates attainment is also unpersuasive because the Basin Plan includes no provisions indicating that these standards are to be applied only at the surface. EPA concludes that absent Basin Plan language to the contrary, these standards apply at all water depths. Based on these considerations, EPA has determined that this water should be identified for inclusion on the list for pH and DO.*

> ***EPA is establishing a low priority for this listing based on the considerations that no specific beneficial use impairments have been associated with DO and pH problems in the Lake, and that additional monitoring is warranted to verify these listings prior to developing TMDLs.*** (emphasis added)

Lake Merced remains on the final California 2008-2010 Section 303(d) list (as approved by USEPA October 11, 2011) as impaired for DO and pH caused by unknown sources. The list indicates that a TMDL is to be completed by 2019. This is the most recent 303(d) list and is not scheduled for updating for Region 2 until the 2016 Integrated Report is prepared.

The SWRCB on September 30, 2004 adopted a *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List* (Resolution No. 2004-0063). This policy provides the currently applicable guidance (that was not in place at the time of the original Lake Merced listing) on criteria to use for adding and removing waterbodies from the 303(d) list including using a weight-of-evidence based approach.

Subsequently, the SWRCB on June 16, 2005 adopted the "*Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options*" (Resolution No. 2005-0050). This policy provides alternatives to TMDLs for addressing 303(d) listings. This policy also provides a rationale for considering complex and variable parameters in environments where there is low DO due to "natural conditions" (e.g., sediment/benthic oxygen demand, limited flushing, diurnal fluctuation, seasonal stratification, etc.). The policy (p. 3, item B) states that:

> *If the failure to attain standards is due to the fact that the applicable standards are not appropriate to natural conditions, an appropriate regulatory response is to correct the standards.*

3.4 Approach to Lake Merced 303(d) Listing and RWQCB Concurrence

In collaboration with SFPUC and RWQCB staff, Daly City developed the "*Proposed Regulatory Process for the Vista Grande Drainage Basin Improvement Project, Lake Merced Alternative*" and submitted it by letter dated March 12, 2013 to the RWQCB staff for their concurrence. The RWQCB staff provided their concurrence by letter to Daly City dated May 9, 2013. The intent of the Regulatory Process Letter (see **Appendix A**) was to identify the steps and elements involved in moving the project forward in coordination with RWQCB requirements.

As noted above, Lake Merced currently does not meet WQOs for DO and pH as defined in the Basin Plan due to naturally occurring seasonal stratification and the Lake is on the 303(d) list for these constituents. The Regulatory Process Letter outlined the two-part regulatory approach for addressing the 303(d) listing. The first part is the development and implementation of a Lake Management Plan and the second part is a Basin Plan amendment to incorporate site-specific implementation provisions for the DO and pH objectives, as discussed further below. The unique conditions of Lake Merced that necessitate site-specific DO and pH implementation provisions include that it is polymictic, a terminal lake, subject to marine coastal influences, and has both an artificially maintained cold water fishery and a self-sustaining warm water fishery.

As part of an approach for maintenance and improvement of the water quality of Lake Merced as part of the proposed project, Daly City and SFPUC have agreed to develop a Lake Management Plan. The Lake Management Plan would define the applicable best management practices (BMPs) that would be implemented to achieve defined goals and objectives for lake water quality management. The plan would also include an operational plan for the proposed Vista Grande diversions, a water quality monitoring plan, evaluation of available BMPs, and an implementation and adaptive management plan. The Lake Management Plan would be developed in consultation with the RWQCB and, if approved by Daly City and the SFPUC, would be implemented pursuant to a legally binding operational agreement between Daly City and the SFPUC.

However, the existing water quality objectives for DO and pH may continue to not always be met throughout the water column, even with implementation of the BMPs defined as part of the Lake Management Plan. This is because the current provisions in the Basin Plan[4] do not acknowledge the potential effects of diurnal and/or seasonal stratification nor of the effects of natural conditions, such as eutrophication, on ambient DO and pH. Consequently, the RWQCB is pursuing the development of site-specific implementation provisions to address the Lake's unique conditions relating to seasonal stratification. This approach (described in Section 3.3, above) is supported by the SWRCB's TMDL Guidance and the Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options (Resolution No. 2005-0050). This policy established that RWQCBs can formally recognize regulatory or non-regulatory actions of other entities as appropriate implementation programs that result in the attainment of standards.

Accordingly, and consistent with regulatory guidance, the RWQCB is considering an amendment to the Basin Plan to incorporate new site-specific implementation provisions for the existing DO and pH WQO to be developed to address the unique conditions of Lake Merced. The State's Impaired Waters Policy also recognizes that water quality standards may be inappropriately applied, making attainment impossible. In such cases, the policy identifies that revision of the standards may be the best or only way to address the impairment.

Daly City, SFPUC, and RWQCB have come to consensus that although implementation of the Lake Management Plan is expected to improve water quality, it would not independently resolve the impairment that regulatorily exists under existing conditions. As a result, following collaboration with Daly City and SFPUC, RWQCB staff agreed that the Basin Plan amendment would involve adopting site-specific objective implementation provisions for Lake Merced specifying how the existing DO and pH numerical objectives would be implemented and evaluated for compliance purposes. Once the Lake Management Plan becomes effective via the operational agreement and the site-specific DO and pH implementation provisions are adopted via a Basin Plan amendment, which would then be approved by the SWRCB, the Office of Administrative Law, and the USEPA, the RWQCB could proceed with recommending to USEPA the de-listing of Lake Merced or other regulatory approaches while the implementation provisions are approved and take effect.

4 *i.e.* the assumption that the DO and pH water quality objectives apply throughout the water column, at all locations and at all times.

3.5 Municipal Stormwater Regulation

The proposed project would reconnect a portion of the historic Lake Merced Watershed that is now part of the Vista Grande watershed in Daly City to allow selected stormwater runoff and authorized non-stormwater runoff to flow to the Lake instead of solely to the Pacific Ocean. Stormwater runoff and authorized non-stormwater flows currently entering the Lake are limited to those from the immediately surrounding San Francisco Lake Merced Watershed. Stormwater flows from Daly City and from San Francisco are regulated under two separate NPDES permits as described below.

3.5.1 Daly City Stormwater Regulation

Stormwater runoff and authorized non-stormwater flows (conditionally exempt discharges) from Daly City and the other San Mateo County cities have been regulated under Phase 1 Municipal Separate Stormwater System (MS4) NPDES permits since 1993. These MS4 permits, including the current Municipal Regional Stormwater Permit (MRP) Order No. R2-2009-0074, have contained increasingly prescriptive requirements, typically in the form of BMPs. The permits require that the cities implement BMPs to the standard defined as the Maximum Extent Practicable (MEP) to minimize the extent of pollutants in stormwater and authorized non-stormwater flows. Annual reports are required to be submitted by co-permittees, documenting compliance with applicable elements of the MRP. Daly City has an effective stormwater management program that fully implements the requirements of the MRP.

The MRP contains extensive monitoring requirements focused primarily on TMDL-based Pollutants of Concern within targeted watersheds and receiving waterbodies, and MRP Provision C.1 specifies how compliance may be demonstrated with receiving water limitations. Provision C.1 states that if exceedances of WQOs persist in receiving waters, MRP Permittees are to "submit a report to the Water Board that describes the BMPs that are currently being implemented, and the current level of implementation, and additional BMPs that will be implemented, and/or an increased level of implementation, to prevent or reduce the discharge of pollutants that are causing or contributing to the exceedance of water quality standards or objectives."

RWQCB staff indicated that the proposed diversions of stormwater from the Canal to Lake Merced are covered under the existing MRP. Daly City understands that no additional NPDES permits are needed for operation of the proposed project.

3.5.2 San Francisco Stormwater Regulation

Stormwater inlets on the streets surrounding the Lake collect stormwater runoff, and route it to the Lake through dedicated drainage pipes (Figure 4-2). Runoff also reaches the Lake by surface sheet flow, mostly on the slopes between the surrounding streets and the Lake. Additional watershed related information is provided in the comprehensive Lake Merced Watershed Report (SFPUC, 2011a). Although San Francisco's population is greater than 100,000, the threshold for Phase I MS4 permit coverage, San Francisco was exempt from Phase I stormwater regulations because most of San Francisco is served by a combined storm sewer system. San Francisco, therefore, must comply with Phase II of the regulations, which became effective March 2003 for jurisdictions in urbanized areas with populations of less than 100,000. Those portions of San Francisco not served by the combined storm sewer system, including the Lake Merced Watershed (described below in Section 4.2.1), are covered by the SWRCB Phase II Small MS4 General Permit that became effective July 1, 2013 (Order No. 2013-0001 DWQ). This permit replaced the first SWRCB Phase II General Permit adopted in April 2003. Stormwater management, monitoring, and reporting requirements under the Phase II permit are extensive and similar to those under the Phase I MRP. The SFPUC Wastewater Enterprise manages stormwater activities under the Phase II permit.

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CHAPTER 4
Lake Merced Existing Conditions

Lake Merced is the largest freshwater lake in San Francisco. It is located in the southwestern corner of San Francisco, bounded by Skyline Boulevard, Lake Merced Boulevard, and John Muir Drive, and is approximately 0.25 mile east of the Pacific Ocean. The Lake was historically a coastal lagoon that was intermittently connected to the ocean via a channel that ran through the current location of the San Francisco Zoo. This connection was permanently closed in 1895 with the construction of Skyline Boulevard and the Great Highway (SFPUC, 2011a). Lake Merced supports limited contact recreational activities including boating and fishing as well as other non-contact uses such as pedestrian use of perimeter paved paths, and trails managed by the San Francisco Recreation and Park Department. The SFPUC also maintains Lake Merced as a non-potable emergency water supply to be used for firefighting or sanitation purposes if no other sources of water are available (SFPUC, 2011a). In the event of a major disaster (i.e., catastrophic earthquake), Lake Merced water could be pumped into San Francisco's drinking water distribution system to maintain firefighting, basic sanitary (e.g., toilet flushing), and other critical needs. In the event of such an emergency, residents would be directed to boil tap water before consuming it. Because of this potential for emergency water supply use, full body contact recreation (e.g., swimming, wading) is not allowed in the Lake (SFPUC Resolution No. 10,435).

The following sections describe the existing conditions related to water quality in Lake Merced, including climate and precipitation, hydrology, water quality, processes that affect lake water quality, and existing biological resources of the Lake.

4.1 Climate and Precipitation

The climate in the Lake Merced area is generally mild, with an annual average temperature of 13 degrees Celsius (°C; 55.4 degrees Fahrenheit [°F]). January is generally the coolest month with an average temperature of 10.5 °C (50.9 °F), while September is the warmest month with average temperature of 15.5 °C (59.9 °F). Average annual precipitation is approximately 20 inches, with a majority of the rain occurring in the winter months. Seasonal average temperature and precipitation data for the period 1948 to 2012 are presented in **Table 4-1**.

TABLE 4-1
AVERAGE REGIONAL TEMPERATURE AND PRECIPITATION

Season	Average Temperature (°F)	Average Precipitation (inches)
Winter (Dec – Feb)	51.5	11.31
Spring (Mar – May)	54.1	4.43
Summer (Jun – Aug)	58.1	0.25
Fall (Sept – Nov)	58.0	3.90
Annual	55.4	19.99

SOURCE: Western Regional Climate Center, Period of Record General Climate Summary for San Francisco Richmond (Station 047767) for years 1948-2012.

4.2 Lake Merced Hydrology

Lake Merced is a naturally occurring lake located adjacent to the Pacific Ocean in the southwestern corner of San Francisco. The Lake is within the San Francisco Coast Watershed, which extends from western San Francisco to the southern end of San Mateo County. The Westside Groundwater Basin underlies most of western San Francisco and extends from the western portion of San Francisco south to the eastern portion of San Mateo County (California Department of Water Resources, 2006). The following sections describe the local Lake Merced Watershed, the Lake, and historic and existing Lake water level elevations.

4.2.1 Lake Merced Watershed

Urban development has significantly reduced Lake Merced's original estimated watershed size of 6,320 acres (approximately 10 square miles) to its current size of approximately 650 acres (SFPUC, 2011a; Kennedy/Jenks, 2012a). Historically, Lake Merced received flows from a number of local surface drainages and creeks, and had an outlet to the Pacific Ocean in the vicinity of what is now the San Francisco Zoo, to the northwest of the Lake. As urban development advanced in the area, surface runoff to the Lake was diverted away from the Lake. Consequently, the southern portion of the original watershed (Daly City), including what is now the Vista Grande Drainage Basin, and the eastern portion of the original watershed (San Francisco) were diverted from flowing into the Lake (**Figure 4-1**; Oakland Museum, 2013). The Lake Merced Watershed is now directly adjacent to the Vista Grande Drainage Basin, which now diverts historic flows south of the Lake directly to the Pacific Ocean via the Canal and Tunnel. Currently, surface flows from within the Basin only enter the Lake during extreme storm events when Canal capacity is exceeded and flood flows cross John Muir Drive into Lake Merced.

The current watershed consists of approximately 626 acres bounded by the adjacent roadways that include Lake Merced Boulevard, Skyline Boulevard, and John Muir Drive. The Lake itself makes up approximately 43 percent of the watershed area (272 acres). The rest of the watershed is composed of upland areas. Harding Park and Jack Fleming Golf Course account for about 175 acres of the upland watershed; roads and neighborhoods account for approximately 31 acres; and the remainder is primarily undeveloped open space vegetated with wetland and upland species including coastal and willow scrub, grassland, herbaceous, and bulrush marsh communities located between the Lake and the surrounding roadways (**Figure 4-2**) (SFPUC, 2011a).

SOURCE: Oakland Museum, 2013

Figure 4-1
Lake Merced Current and Historic Watershed

Much of the runoff from the original watershed is now diverted into the San Francisco combined storm sewer system, resulting in reduced natural drainage and recharge to the Lake. This runoff diversion makes it difficult to define the limits of the contributing drainage areas that make up the Lake Merced Watershed because it is not clear exactly how many of the inlets located within the Lake's natural drainage basin are now part of the San Francisco's combined storm sewer system, and because the areas served by these inlets are difficult to accurately delineate (SFPUC, 2011a). Development of the Lake's current watershed increased impervious surfaces, which tends to increase surface water runoff from land areas rather than promote infiltration into the ground. A significant portion of stormwater that falls on the areas immediately surrounding the Lake drains directly into the Lake. Stormwater inlets on the streets surrounding the Lake collect stormwater runoff, and route it to the Lake through dedicated drainage pipes (SFPUC, 2011a). Additionally, several catch basins draining into the Lake are located primarily along the southern portion near Impound Lake, and the majority of the stormwater drains located along the western shore of Lake Merced (Figure 4-2) empty directly to the Lake (Kennedy/Jenks, 2012a; SFPUC, 2011a). Overflow from the Canal during extreme storm events has historically been discharged into the Lake (described below). The proposed Project would re-establish this historic surface water connection between Daly City (Vista Grande Drainage Basin) and Lake Merced within the watershed.

4.2.2 Lake Merced

Originally not a lake at all, Lake Merced historically had a larger shoreline and was characterized as a coastal lagoon that periodically connected directly to the ocean via a channel that ran through what is currently the San Francisco Zoo. The outlet was permanently closed in 1895 in order to expand Skyline Boulevard and the Great Highway and allow the Spring Valley Water Company to convert the lagoon to a reservoir. The existing shape of Lake Merced is typical of a former river-estuary channel, with a rounded rectangular basin, fairly steep sides and a long, narrow trench close to the northeast shore, though it is no longer connected to the ocean. The permanent closing of the outlet to form Lake Merced substantially altered the hydrology of the lake which also precipitated a shift in lake water quality. Freshwater gradually replaced the saltier ocean water (SFPUC, 2011a). Dissolved salts, such as carbonates and sulfates from basin inflows and sodium and chloride from sea spray, entering the lake were retained (rather than flushed out via the hydrologic connection to the ocean) and also concentrated over time as a result of annual evaporation. Such a hydrologic shift has likely resulted in the entire lake becoming increasingly alkaline, as compared to historic conditions, with a higher baseline pH (discussed further in Section 4.3).

North and South Lakes are hydrologically connected via a conduit, although this connectivity is limited (SFPUC, 2011a). North and East Lakes are hydrologically connected via a narrow channel under a pedestrian bridge. Impound Lake was formed with the construction of a sewer line across the southern tip of South Lake which restricted the hydrologic connection so that flow between South and Impound Lakes occurs only when WSE is above 4.3 feet City Datum. South Lake, which has a surface area of approximately 175 acres, is the largest of the lakes, and contains more than two-thirds of the total volume of all four lakes. Following in order of size, North Lake is approximately 58 acres, East Lake is approximately 26 acres, and Impound Lake, the smallest and southernmost lake, is approximately 13 acres. Water depth varies between the four lakes, with Impound Lake being the shallowest with depths ranging from 2 to 10 feet, and an

Legend

- Stormdrain Catch Basin
- Stormdrain Manhole
- Stormdrain Junction
- Vista Grande Canal
- Stormdrain Line
- Adjacent to Lake (123 Acres)
- Impervious Areas (31 Acres)
- Harding Park Golf Course (183 Acres)

SOURCE: ESRI Onlin Aerial Imagery, 2007 (2ft resolution)
Stormdrain Data from SFPUC, 2008;
Kennedy/Jenks Consultants

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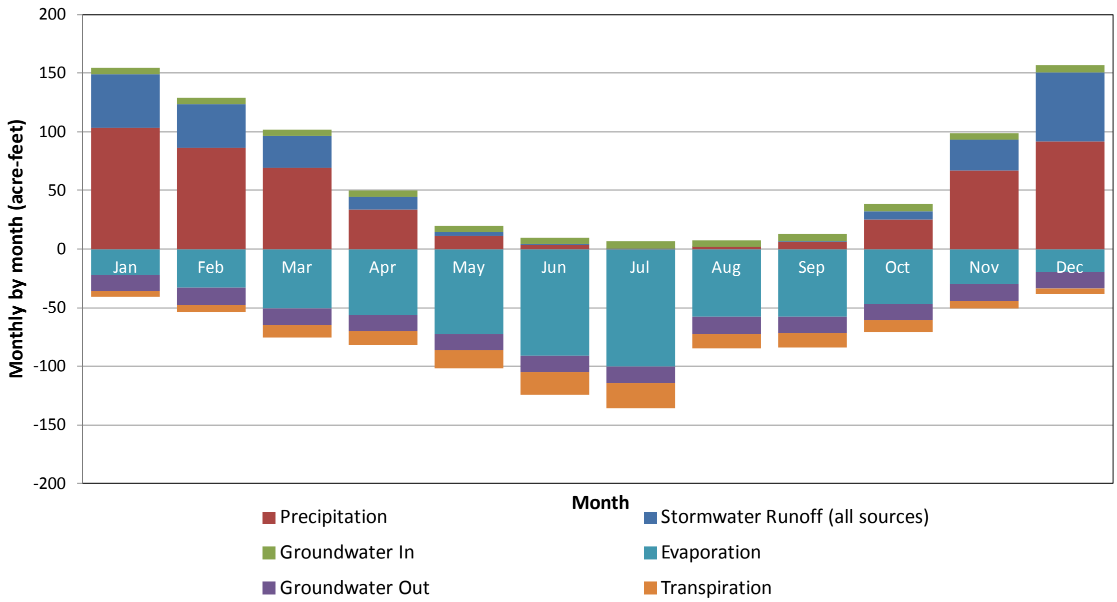
Figure 4-2
Lake Merced Watershed

\average depth of roughly 5.5 to 6 feet. North and East Lakes range in depth from 3 to 20 feet, with an average depth of 10 to 11 feet. South Lake depths range from 3 to 21 feet, with average depths of roughly 13 to 15 feet (SFPUC, 2011a).

Lake Merced is currently replenished primarily by direct precipitation, limited runoff from immediately adjacent areas, periodic overflows of the Canal, and shallow groundwater inflow (**Figure 4-3**). The only physical outlet from Lake Merced is from South Lake via a 30-inch-diameter overflow conduit at a WSE of approximately13 feet City Datum that connects to the Tunnel immediately downstream of the Canal. Currently, the largest source of outflow is evaporation, followed by transpiration, and groundwater infiltration.



SOURCE: ESA

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Figure 4-3
Lake Merced Sources of Inflow and Outflow

The total combined surface area of all four lakes has historically ranged from 190 to 319 acres, depending on water level, with a corresponding total volume that ranged from 1,800 to 7,780 acre-feet. In recent years, with an annual mean WSE of 6 feet City Datum, the Lake is estimated to have a total area of 296 acres and a total volume of 5,625 acre-feet.

Water levels in Lake Merced fluctuate seasonally and across different time periods. Prior to 1935 (before the completion of the Hetch Hetchy water system), the Lake was used for municipal water supply. Lake WSEs typically ranged from -10 to 0 feet City Datum, but increased to over 13 feet City Datum by the late 1930s and early 1940s after water deliveries from the Hetch Hetchy water system began (Kennedy/Jenks, 2012b). However, WSEs began to decline again in the 1940s. During the 1940s to late 1950s, WSEs varied between 8 and 13 feet City Datum. Between the late 1950s and early 1980s, lake levels experienced a long-term declining trend, with WSEs ranging between 4 and 10 feet City Datum. The reasons for the overall decline in lake levels between the 1940s and 1980s are reported to be drought, increased municipal groundwater pumping in the

Westside Groundwater Basin, and diversion of stormwater runoff due to increased urbanization and development of the watershed.

During the late 1980s and early 1990s, Lake Merced WSEs declined to well below historical averages. The lowest WSE observed was about -3.2 feet City Datum in 1993 following the major drought of the late 1980s and early 1990s. Since that time, the WSEs have steadily risen as a result of above-average precipitation, SFPUC water additions to the Lake between 2002 and 2005, reduced irrigation pumping at the Lake Merced-area golf courses as a result of recycled water deliveries, and reduced municipal groundwater pumping as a result of the In-Lieu Recharge Demonstration Study[5] (see **Figure 4-4** for 1926 to 2011 water levels). Since 2006, lake levels have consistently remained between about 5 and 7 feet City Datum. In 2009, the WSE ranged from approximately 4.9 to 6.9 feet City Datum (Kennedy/Jenks, 2012b). As of December 2011, the WSE was approximately 6.8 feet City Datum, though in April 2011, the Lake had reached 7.4 feet City Datum, its maximum WSE in 2011 (SFPUC, 2011).

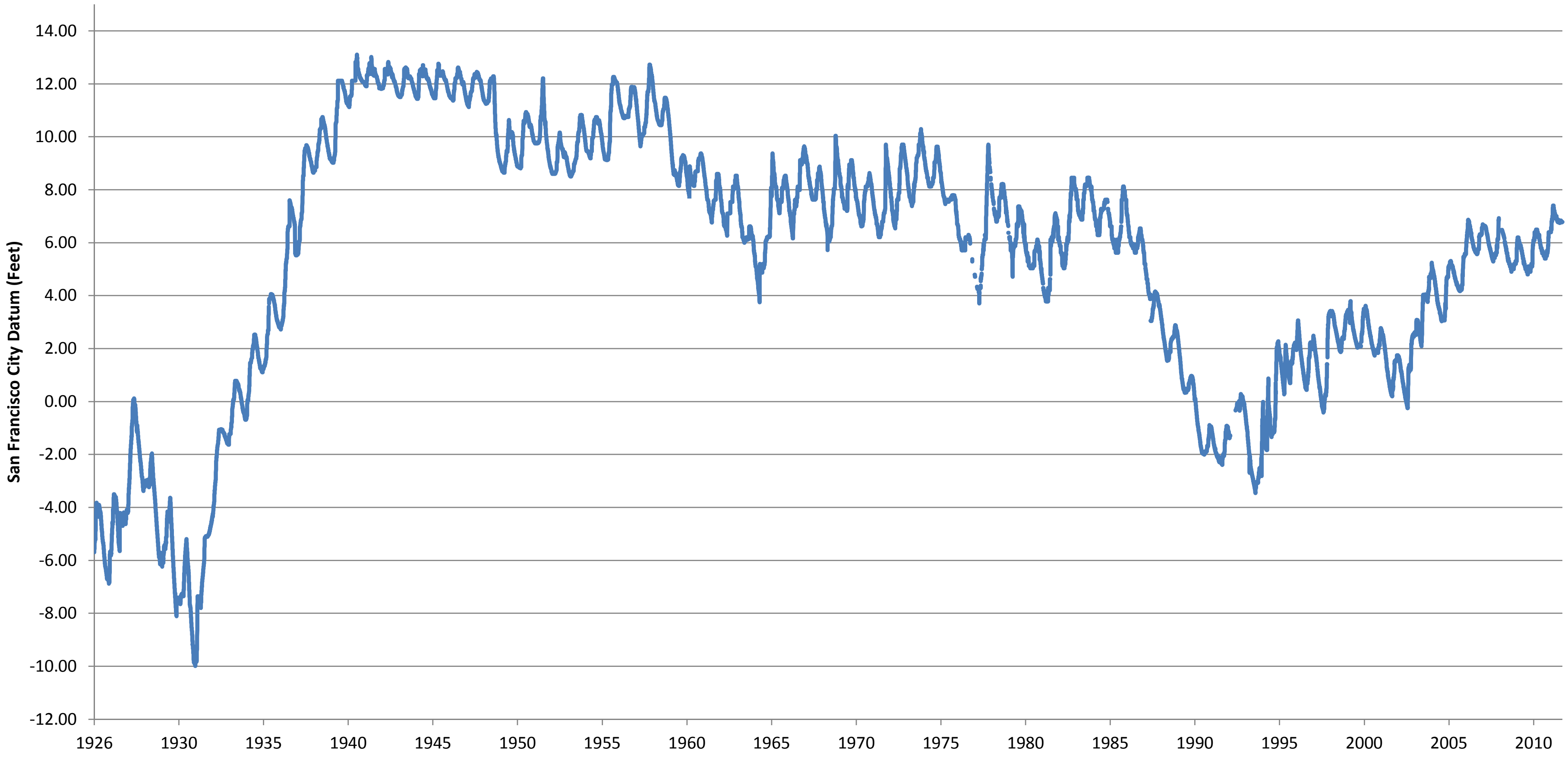
4.3 Lake Merced Water Quality

4.3.1 Previous Lake Merced Water Quality Monitoring

The water quality assessment for Lake Merced includes a review of data on historic and baseline water quality conditions, which were gathered from several existing water quality data sources and reports. The largest and most robust historic data set reviewed was compiled by SFPUC as part of routine monitoring in Lake Merced. The SFPUC data is collected over a wide spatial area; monitors a broad range of water quality parameters at multiple depths throughout the year, and includes over 10 years of consistent monitoring. For these reasons, the SFPUC data is the focus of the following section.

The SFPUC has in the past and continues to monitor a broad range of water quality parameters at various depths within Lake Merced on a quarterly basis. Monitoring is conducted at four locations identified as North, Northeast, South-Pistol Range, and South-Pump Station, as shown on **Figure 4-5** (Kennedy/Jenks, 2010). Water sampling is conducted between three and eight times per year but is typically conducted quarterly. For the majority of the parameters tested, samples at each location are collected at various depths, starting at the lake surface, and decreasing at 5-foot intervals to the lake bottom.

5 From October 2002 through April 2007, the SFPUC and three Partner Agencies (Daly City; California Water Service Company [Cal Water]; and the City of San Bruno) participated in the In-Lieu Recharge Demonstration Study in the South Westside Groundwater Basin to study the effects of the groundwater recharge component of a conjunctive use program. During the Demonstration Study, the Partner Agencies received approximately 20,000 acre-feet of supplemental surface water from the SFPUC "in-lieu" of their normal groundwater pumping. The purpose of the study was to determine if providing supplemental water to the Partner Agencies would result in increased groundwater availability for pumping in dry years and for emergency supply when the SFPUC regional water supply may be reduced. The 20,000 acre-feet of groundwater savings accrued under the Demonstration Study was credited to an SFPUC Storage Account. However, this water would not be withdrawn unless the SFPUC approves the Groundwater Storage and Recovery Project, the SFPUC and the Partner Agencies approve the associated Operating Agreement, and the Groundwater Storage and Recovery Project wells are constructed to enable use of the water in storage (Kennedy/Jenks, 2012a).



SOURCE: ESA, 2013

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Figure 4-4
Historical Measured Lake Merced
Water Surface Elevation (1926 to 2011)

SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-5
SFPUC Lake Merced Water Quality Monitoring Locations

Kennedy/Jenks Water Quality Assessment

In 2010, Kennedy/Jenks Consultants evaluated SFPUC water quality data collected from 1997 to 2009 (Kennedy/Jenks, 2010, included in **Appendix D**) to determine if Lake Merced's "health" had improved, remained constant, or degraded over time. Based on a review of the data, water quality parameters that represent lake conditions can be grouped as:

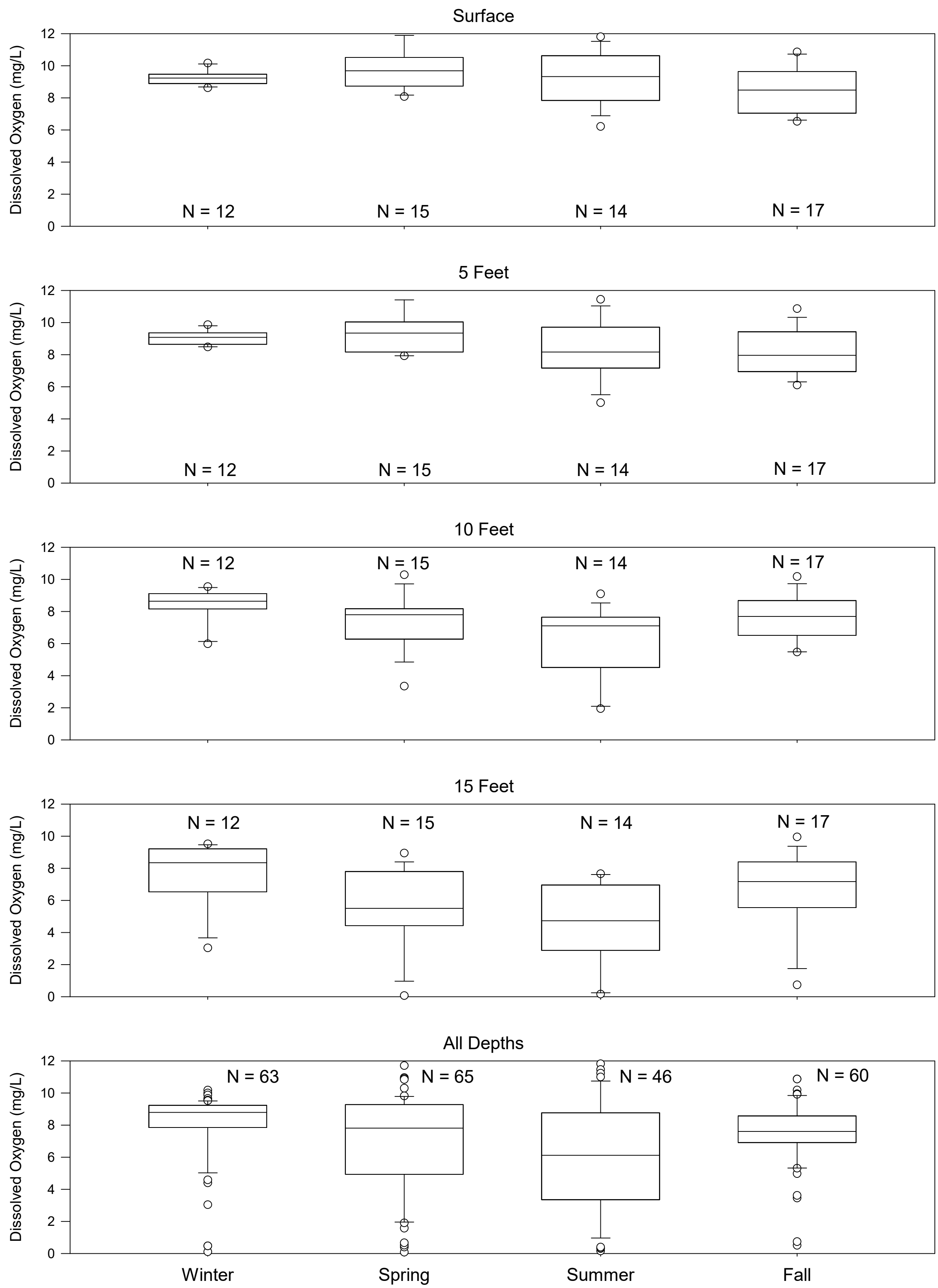
- DO, a measure of the amount of dissolved oxygen in water, which is an indicator of fish habitat and healthy biological processes;
- Secchi depth, which is a measurement of lake clarity, and can be affected by algae production and suspended solids;
- Algae, as well as total available nitrogen, and nitrogen-to-phosphorous ratio (N:P), which are indicators of algal production and nutrients, both of which affect long-term lake health; and
- Total coliform and *Escherichia coli* (*E. coli*), both of which are indicators of pathogenic microorganisms and fecal contamination.

The 2010 Kennedy/Jenks evaluation concluded that the water quality of Lake Merced remained relatively constant from 1997 to 2009, and that the lake clarity (Secchi depth) improved slightly. During the 1997 to 2009 sampling period, no substantial changes in average algal biomass levels occurred, although there were periodic increases in concentration due to algal blooms.

DO levels measured between 1997 and 2009 remained above the warm water habitat objective of 5 mg/L and the cold water habitat objective of 7 mg/L for the majority of the data set, although episodes of DO lower than 5 mg/L occurred (**Figure 4-6**) (Kennedy/Jenks, 2010). It was determined that DO levels were affected by the naturally occurring periods of weak stratification.[6] While long-term anoxia in the hypolimnion was not observed, episodes of DO lower than 5 mg/L occurred periodically during the summer and late fall in the deeper portions of the Lake. DO measured at the surface down to 5 feet depth always exceeded 5 mg/L. An increasing trend in DO was found for the 13-year data set, although the trend is not statistically significant. Additionally, the data indicate that significant additions of nutrients due to low DO and internal nutrient cycling (discussed further under "Processes affecting Lake Water Quality") do not occur.

Lake Merced is an alkaline lake (discussed further in Section 4.3.2) with a pH range of approximately 7.5 to 9.3. The average pH across all depths sampled over the same 13-year period was 8.1, within the range of Basin Plan WQOs of 6.5 to 8.5 and near the level of 8.3 which would result from equilibrium with carbon dioxide in the atmosphere. The pH levels appear to be the result of photosynthesis from algal activity, combined with the elevated alkalinity within the Lake due to it being a terminal lake, with no regularly occurring outflow since it lost connection to the

[6] Lake stratification is the separation of a lake into three layers: the top of the lake, referred to as the epilimnion; the middle of the lake, referred to as the metalimnion; and the bottom layer of the lake, referred to as the hypolimnion. The amount of lake stratification can vary over the day as well as seasonally, depending on a number of factors (discussed further under "Processes affecting Lake Water Quality").



SOURCE: Kennedy/Jenks Consultants, 2010;
ESA, 2013

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Figure 4-6

Lake Merced South - Pump Station: Dissolved Oxygen 1997 to 2009

Pacific Ocean in the late 1900s. Overall, a statistically significant decreasing trend in pH was found for the 13-year data set, indicating an improvement in water quality (**Figure 4-7**) (Kennedy/Jenks, 2010).

SFPUC calculated various summary statistics (median, minimum, maximum, standard deviation, and coefficient of variance) for the water quality data collected between 1997 and 2009 (SFPUC, 2010). **Table 4-2** provides a data summary for key nutrient- and algal-related parameters, as well as temperature, DO, and pH.[7] The key nutrient- and algal-related parameters demonstrate that Lake Merced is strongly nitrogen-limited and has been since at least 2000. Algae blooms typically occur in the fall, and bioavailable nitrogen typically peaks in the winter or spring.

TABLE 4-2
DATA SUMMARY OF KEY NUTRIENT AND ALGAL RELATED PARAMETERS
(SOUTH LAKE PUMP STATION)

Parameter	Units	1997-2009					Number of Sampling Dates
		Median	Min.	Max.	Standard Deviation	Coefficient of Variance	
Temperature	ºC	16.3	9.8	21.8	3.10	0.20	59
Dissolved oxygen (DO)	mg/L	7.8	ND	12.2	2.8	0.39	58
pH	-	8.1	6.8	8.8	0.3	0.04	59
Ammonium (NH_4+)	mg/L	0.04	ND	0.65	0.07	1.22	57
Nitrate (NO_3-)	mg/L	ND	ND	0.62	0.09	2.80	59
Orthophosphate	mg/L	0.05	ND	0.23	0.05	0.86	59
Total Kjeldahl nitrogen (TKN)	mg/L	2.38	ND	28.2	3.67	1.00	55
Total Phosphorus	mg/L	0.15	ND	0.40	0.06	0.41	58
Chlorophyll	µg/L	23	5	100	15	0.58	53
Secchi depth	feet	1.8	1.0	3.0	0.5	0.27	59

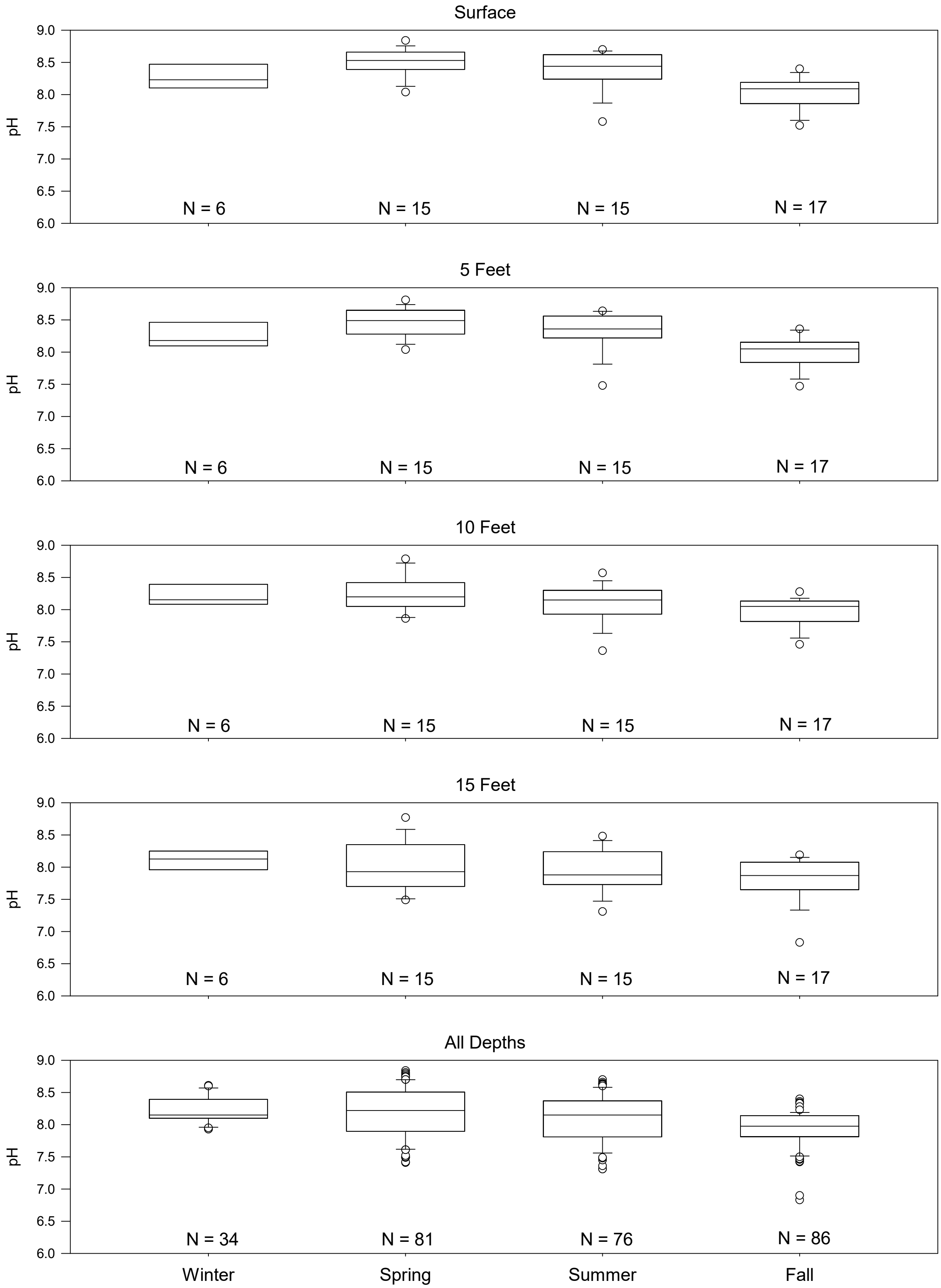
NOTES:
ND – Non-detect

SOURCE: SFPUC, 2010

4.3.2 Lake Merced 2011-2012 Monitoring

Review of existing water quality data and reports for Lake Merced (Section 4.3.1) and the Canal (Section 5.2.1), identified additional information needed to prepare a thorough assessment of potential water quality effects from proposed diversions from the Canal to Lake Merced. The quarterly monitoring data collected by SFPUC in Lake Merced provided broad scale baseline water quality conditions, but did not provide the more detailed seasonal, spatial (depth), and

[7] **Appendix A** contains a more detailed graphical summary of results over this 1997 to 2009 time period from the South Lake (Pump Station) SFPUC monitoring location, including temperature, DO, pH, ammonia, nitrate, and total phosphorus.



SOURCE: Kennedy/Jenks Consultants, 2010; ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-7
Lake Merced South - Pump Station: pH 1997 to 2009

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Exhibit 6
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temporal (hourly) DO and pH data necessary to establish the baseline water quality of the potential receiving waters (South Lake), particularly relative to the USEPA 303(d) listing.

In response to the need for additional data to document the seasonal, spatial and temporal variations in DO and pH in South Lake and overall potential “source” water quality within the Canal, a monitoring program was designed and implemented for the 2011 and 2012 dry and wet season periods. Development of the monitoring program incorporated input from and review by SFPUC and RWQCB staff. The sections below provide an overview of the water quality sampling methodology, results, and analysis, as defined by the monitoring program.

Methods for 2011-2012 Lake Merced Monitoring

Dry season and wet season water quality monitoring plans were developed for South Lake and the Canal to establish baseline water quality characteristics within the Lake for DO and pH and for overall water quality within the Canal. The dry and wet season plans (*Final 2011 Dry Season Water Quality Monitoring Plan – Vista Grande Drainage Basin Improvement Project, September 16, 2011; Final 2011-2012 Wet Season Water Quality Monitoring Plan – Vista Grande Drainage Basin Improvement Project, November 17, 2011*, **Appendix B**) included NPDES-compliant sampling and analytical methodologies and detection limits. Monitored constituents included those typically present in urban stormwater and non-stormwater runoff (nutrients, metals, and bacteria).

Water quality monitoring data collection was conducted in 2011 and 2012 to characterize water quality during seasonal dry and wet annual periods. Dry season water quality monitoring was conducted between August 15 and October 31, 2011 and wet season monitoring was conducted from November 20, 2011 to May 31, 2012. Monitoring was conducted concurrently in the Canal and South Lake using consistent analytical methods to assess a similar set of water quality parameters.

For both dry and wet season monitoring, four monitoring locations were identified within Lake Merced based on review of historic data (Kennedy/Jenks Consultants, 2010) and the potential discharge location (as of Fall 2011) of the stormwater from the proposed constructed treatment wetland into the southern portion of South Lake. (As described in Chapter 2, Project Description Overview, the proposed discharge location is now at the central western shoreline of Impound Lake). Additionally, one monitoring location was identified within the Canal for concurrent monitoring.

Continuously recording (hourly) water quality data loggers were installed at the four Lake Merced locations to record pH, DO, specific conductance, and temperature. The data loggers were deployed in August 2011 and removed in January 2013. The loggers recorded water quality at multiple depths between the surface and Lake bottom. One continuously recording (hourly) water quality logger was also installed at the monitoring location within the Canal to monitor the same parameters.

As shown in -, the monitoring and data logging stations included:

- **Station LM-1:** located approximately midway across the SFPUC's sewer transport structure separating South Lake and Impound Lake (data logger at 1.5 foot depth).
- **Station LM-2:** located at a public access floating dock between LM-1 and LM-3 (data loggers near surface and approximately 8 feet).
- **Station LM-3:** located approximately 1,000 feet northwest of the SFPUC's sewer transport structure separating South Lake and Impound Lake and adjacent to the existing riprap Canal overflow discharge structure (data loggers near surface and approximately 15 feet).
- **Station LM-4:** located at a point that has been used by the SFPUC for monitoring water quality in the South Lake since 1997 (allowing comparison of the 2011 dry and wet season monitoring data to the larger historic record) and has been determined to be representative of the overall water quality of South Lake (Kennedy/Jenks Consultants, 2010). (Routine surface grab sampling and data loggers at near surface, 10, 15, and 20 feet).
- **VGC-1:** located within the Canal for hydrologic monitoring and water quality sampling. This location was selected to avoid inclusion of monitoring data that includes backwatering or velocity changes that may occur at some constricted points along the Canal.

During the 2011 dry season, grab samples were collected twice monthly at the Lake surface at the LM-4 monitoring station and delivered to a California-certified analytical laboratory for analysis of the water quality constituents (see Appendix B). Additional details regarding the analytic methods used, frequency of sampling conducted, and other aspects of the monitoring study are presented in the 2011 Dry Season Water Quality Monitoring Plan (Appendix B). Dry season samples were collected on August 17, September 1, September 15, September 30, October 13, and October 27, 2011. During the wet season, collection of grab samples at LM-4 was synchronized with collection of water quality samples from the Canal. Samples were collected within 24 hours of rainfall that generated sufficient storm flow for successful sampling within the Canal (discussed further in Section 5.2.2).

Subsequent samples were also collected from LM-4 approximately 24 hours after the cessation of a precipitation/runoff event for analysis of microbiological constituents to characterize and assess changes in bacterial concentrations in Lake Merced following contribution of storm flows from the San Francisco portion of the watershed that contributes runoff to the Lake. Additionally, samples were collected during dry weather interludes. These grab samples were delivered to a California-certified laboratory for analysis of a suite of water quality constituents (listed in Appendix B). Wet season storm samples were collected on January 20, January 23, February 29, and March 14, 2012. Wet season non-storm samples were collected on January 13, February 6, and February 17, 2012.

Results of 2011-2012 Dry and Wet Season Monitoring

Appendix B includes detailed results of the dry and wet season monitoring conducted as part of the proposed project (including the results of Canal water quality monitoring). The following sections discuss the monitoring results for temperature, DO, and pH, which are the focus of the Chapter 6 analysis. The sections below also discuss monitoring results for other constituents as

SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-8
2011-2012 Water Quality Monitoring Locations

they relate to DO and pH, and the interrelated lake processes discussed in Section 4.4. Results presented below include a summary discussion of analyses and interpretation of lake processes presented by Dr. Horne (2012a) as part of his modeled analysis of water quality effects to Lake Merced from the diversion of Canal flows (presented in its entirety in **Appendix E**). Section 4.3.3 and Appendix B include additional discussion and summary plots for results of the full monitoring period through January 2013.

Temperature

Temperature data collected from August 2011 to January 2013 indicate that from approximately mid-October through mid-April, the Lake is well mixed with a relatively uniform temperature profile throughout the water column. Water temperatures during that period range from about 10 °C to 18 °C. From late spring through early fall; however, rising air temperatures and solar radiation initiate stratification when the surface layers of the Lake are warmed by the sun. In June and July, surface water temperatures regularly exceed 20 °C while hypolimnion temperatures are often above 18 °C.

Dissolved Oxygen

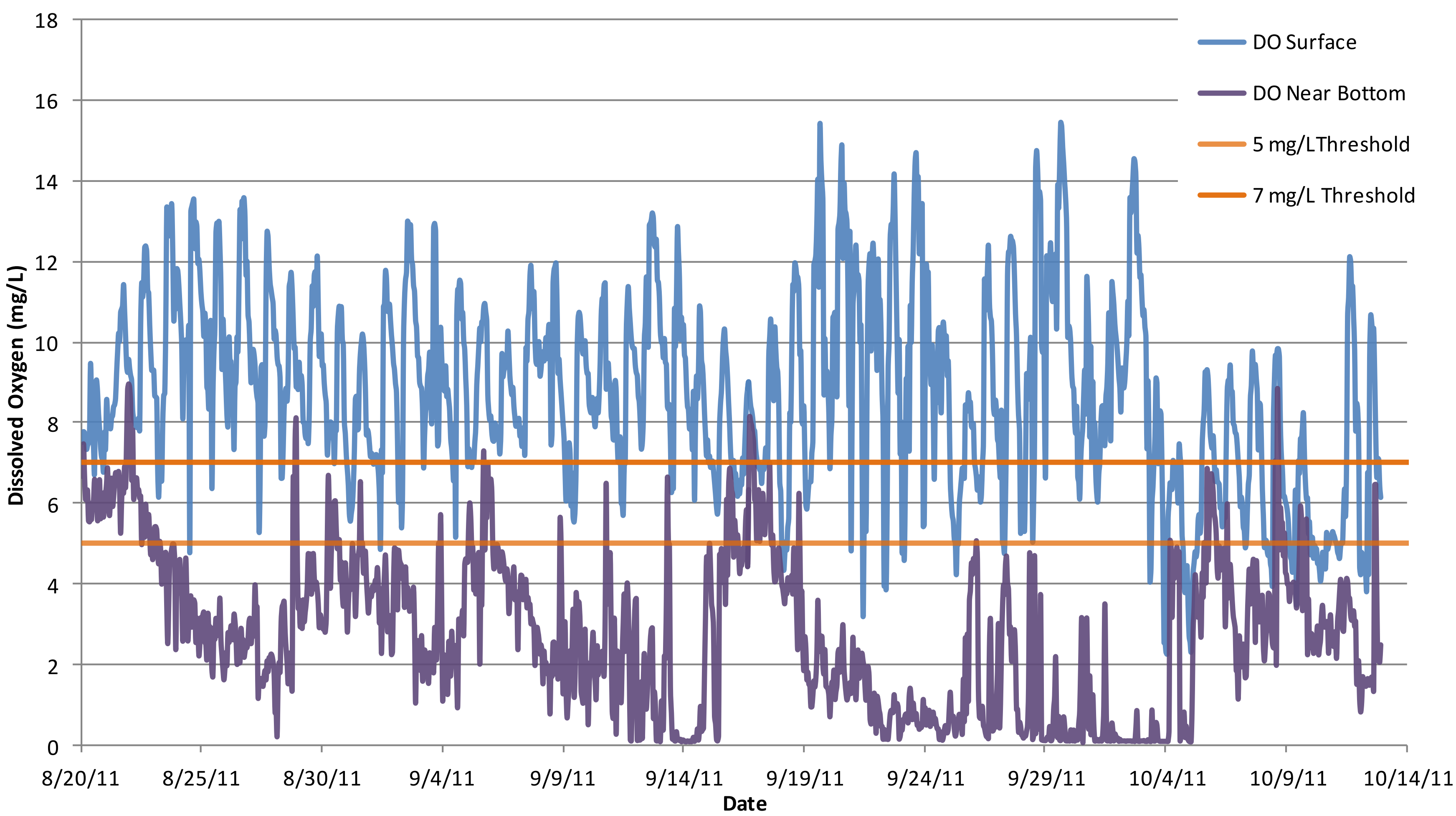
During the initial period of continuous monitoring (August 20 to October 14, 2011), DO near the bottom of the water column was above the 5 mg/L criterion for only about 5 percent of the period, due to seasonal stratification broken up by intermittent weak mixing events. Functional anoxia (less than 2 mg/L DO) for several weeks is required in the bottom waters before the sediments release substantial amounts of ammonia and phosphate. In Lake Merced, functional anoxia occurred in 2011 at near-shore station LM-3 for 34 percent of the time (19 non-continuous days with the longest continuous period being only 4 to 5 days) (**Table 4-3**). Thus, for about 66 percent of the time, some oxygen was present, albeit between 2 and 5 mg/L. **Figure 4-9** shows these fluctuations in DO content. Based on the small changes in ammonia and total-P in the same seasons, the short and intermittent period of functional anoxia does not appear long enough to substantially increase sediment nutrient flux.

TABLE 4-3
WATER QUALITY AND DEPTH RELATIONSHIPS IN SOUTH LAKE

Time period	Percentage (%) of time DO > 5 mg/L below 15 feet	Percentage (%) of time DO < 2 mg/L below 15 feet	Comment
Aug-Oct 2011 *(WSE 6.8 ft)*	5% (2 days)[a]	34% (19 days)[a]	DO usually below 5 mg/L standard but functional anoxia less common
June-Aug. 1997-2003 *(WSE 0 to 3.8 ft)*	38	50	Apparent increase[b] in duration of functional anoxia.
Sept-Nov. 2004-2010 (*WSE 4 to 7 ft)*	50	80	Increase in lower DO.

NOTES:
[a] Not continuous.
[b] Duration of functional anoxia between the two periods (1997 to 2009) and the 2011 data do not correspond exactly since different time periods are averaged and there are many more measurements in 2011.

SOURCE: 2011 data from the LM-3 probe; 1997 through 2009 data from SFPUC, 2009.



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-9

Dissolved Oxygen in South Lake, August - October 2011

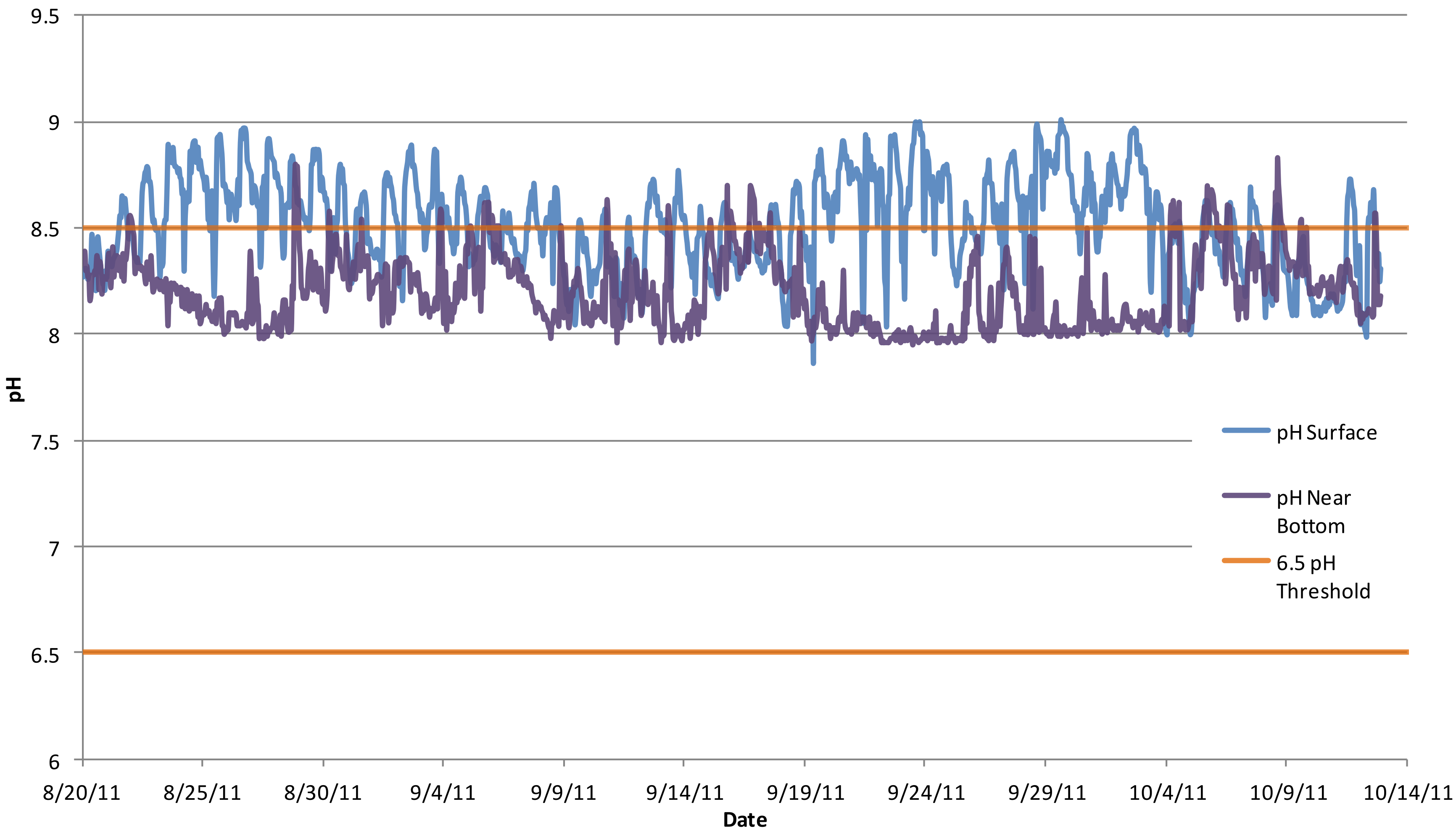
As described in Section 4.3.1, periodic measurements of water quality by SFPUC are available for the last 12 years and provide context here for the DO conditions described above. Readings of DO were taken in most years between 1997 and 2010, but normally only once per year for the critical summer-fall period, and not always in the same month. There was a series of years with relatively low water levels (1997 to 2003; WSE 0 to 3.8 ft.) and a similar period of higher water levels (2004 to 2010; WSE 4 to 7 ft.). Increased depth did reduce DO in deep water (Table 4-3). The effect was most pronounced in autumn. The bottom DO in September-October 1997 to 2003 was greater than 5 mg/L for 50 percent of the time, but only for 20 percent of the time from 2004 to 2010. However, no negative effects on algae or water clarity occurred when the incidences of low DO in deep water increased. In fact, any potential adverse effect due to lower DO in the deep water seemed to have been more than balanced by beneficial effects of deeper water since water clarity increased and nitrate, pH, and turbidity declined (Kennedy/Jenks, 2010).

pH

Lake Merced has a widely fluctuating and elevated pH range, particularly in the portion of the water column near the lake surface. As shown in **Figure 4-10**, the removal of acidic carbon dioxide on summer afternoons by algal photosynthesis frequently raises the pH of surface water layers above 8.5, typically occurring for about 6 hours, corresponding to peak sunlight periods, and ranging from about 1 to 24 hours in duration. Importantly, the Lake's range of pH (approximately 7.5 to 9.3) is always on the alkaline side and never reaches neutrality (pH 7). Since carbonic acid is produced following decomposition in the sediments, lower pH than that measured in Lake Merced is typically found in deep water at most lakes.

The higher pH values in Lake Merced are not typical for a system such as Lake Merced, given the sandy (acidic) nature of the Lake's drainage soils which should produce a more acid runoff water. Rain is acidic (pH equilibrium 5.7) and should not be easily neutralized passing though sandy soil. Due to its expected acidic drainage and by comparison with similar lakes, more acidic water would be expected in Lake Merced. Lower surface pH (approximately 8) did occur at night on most days but only occurred during the day during the one chemical holomixis (top-to-bottom mixing) event recorded for the initial 2011 monitoring period (October 17 and 18). High pH occurs on almost every day in summer and fall and was similar between 1970 and 2010 (San Francisco Water Department as cited in Matuk and Salcedo, 2000; SFPUC, 2009). Although high pH occurrences are common in eutrophic lakes in the later morning and early afternoon, the frequency, duration, and temporal patterns of high pH found in Lake Merced are not consistent with the Lake's eutrophic state and algal abundance (chlorophyll an approximately 28 micrograms per liter [µg/L]). Typically, higher pH values would be expected in the day and lower pH values would be expected at night or on cloudy days (Straskraba, 1986).

The best explanation for the observed cycle of the highest pH occurring in the day and lowest at night is algal photosynthesis (described in detail in Horne, 2012b, included as Appendix E). The cycles of high pH in Lake Merced are due to algal photosynthesis in the day and respiration by algae, zooplankton, and fish at night, on top of a high background pH due to the naturally high concentration of salts like carbonates or alkaline salts.



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-10

pH in South Lake, August - October 2011

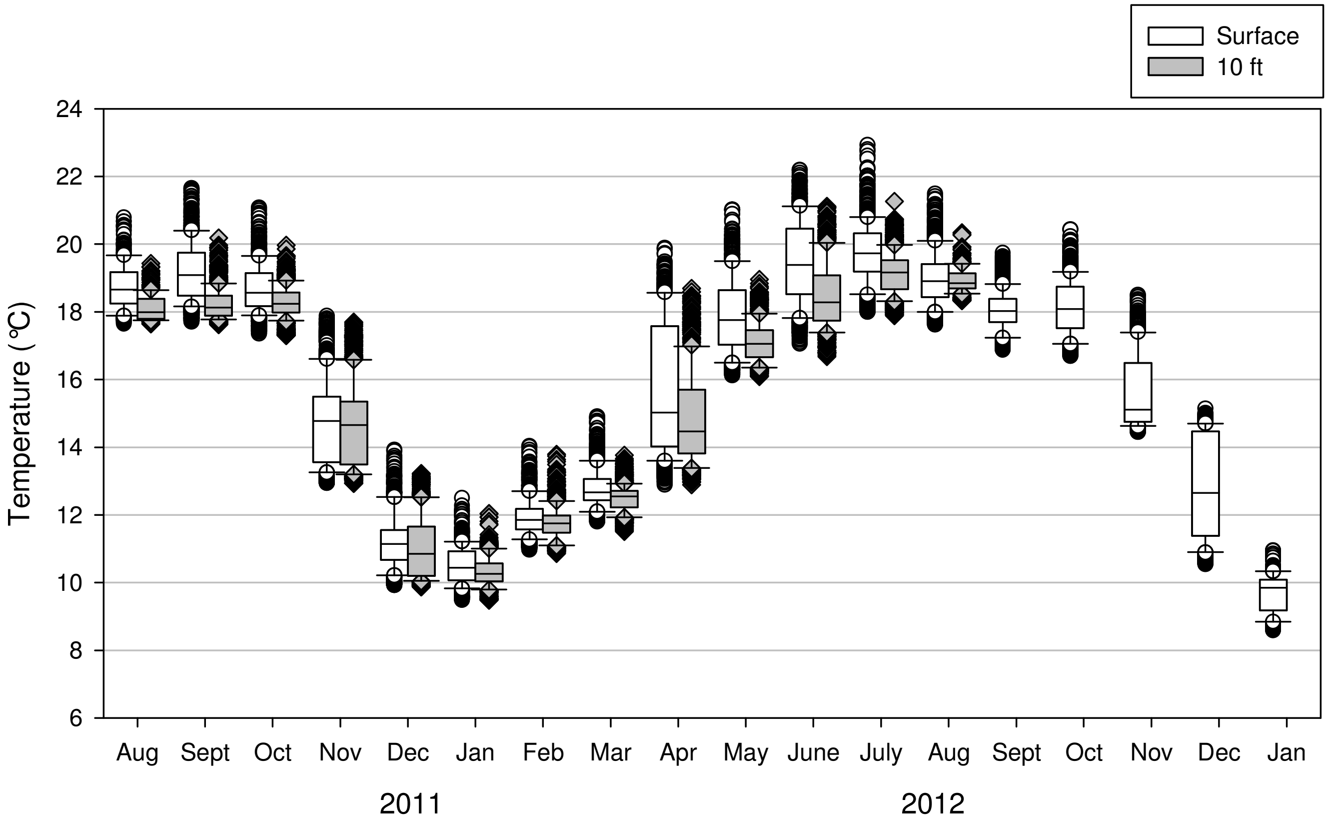
4.3.3 Extended Monitoring Results

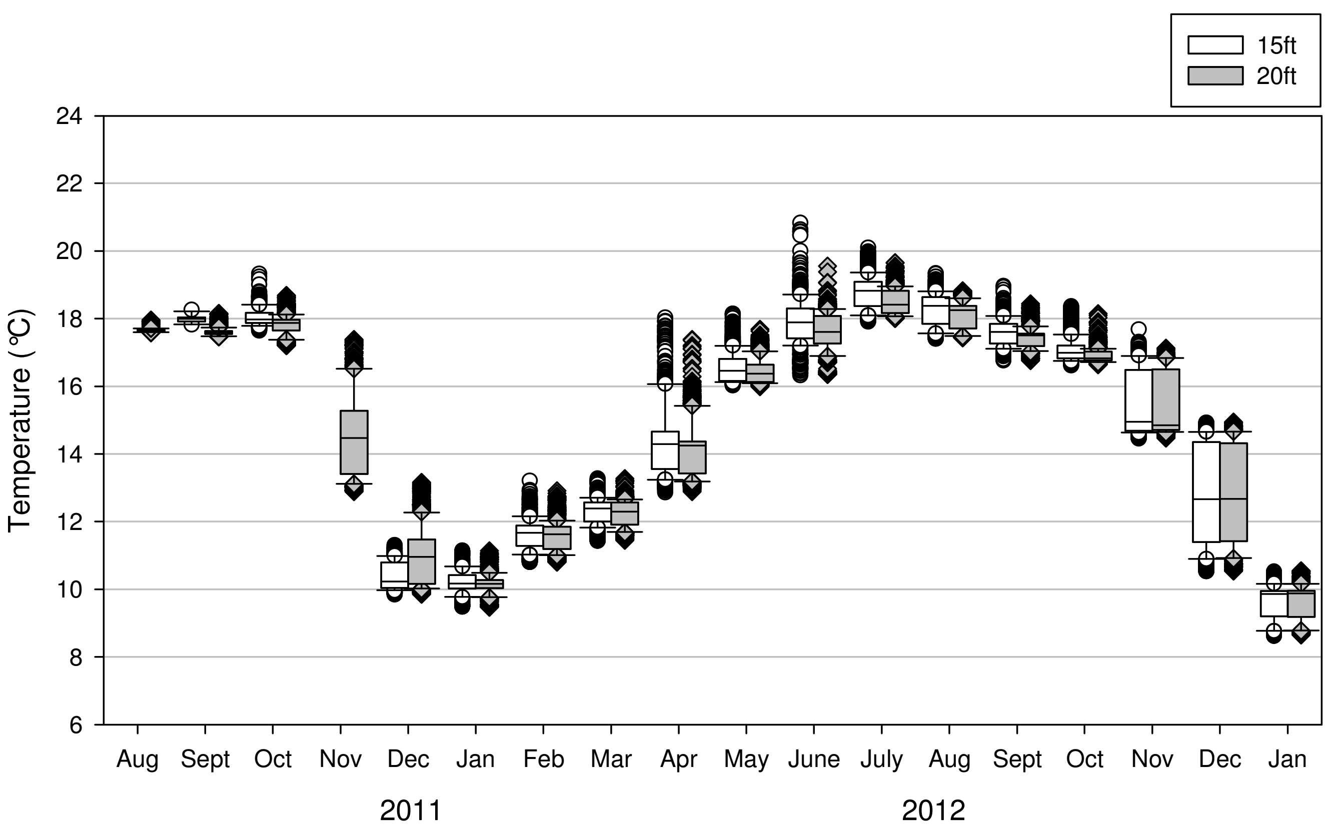
Subsequent to the initial 2011 continuous monitoring and analysis of Lake Merced water quality conditions described in Section 4.3.2, above, additional monitoring data were collected as part of the 2011-2012 program through January 2013. These data provide a multi-year insight into seasonal variability and stratification conditions that occur within Lake Merced. Also, as part of the extended monitoring, additional continuous water quality sondes were added at station LM-4 to monitor water quality at more and lower discrete depths as LM-4 was determined to be the most representative of overall lake conditions. The results of the extended water quality monitoring are consistent with the initial 2011 trends described in Section 4.3.2. **Figures 4-11** through **4-13** summarize the extended monitoring results for temperature, DO, and pH, respectively and include a summary of continuous time series monitoring data for DO (**Figure 4-12b**) and pH (**Figure 4-13b**), collected at a range of depths at location LM-4. The continuous time series results demonstrate trends and fluctuations of DO and pH observed over the course of one full year at four discrete monitoring depths within the Lake. Also summarized are continuous time series results for DO (**Figure 4-12c**) and pH (**Figure 4-13c**), where the results for the surface and 10-foot depths averaged and then the 15- and 20-foot depths averaged for comparison to demonstrate the naturally occurring seasonal DO and pH fluctuations within the epilimnion and hypolimnion. **Figures 4-14** through **4-16** summarize the trend of natural fluctuation in temperature, DO, and pH levels, respectively, over a 48-hour period. Such fluctuations occur as a result of diurnal variability in algal photosynthesis and solar warming (discussed in Section 4.4, below).

4.4 Conditions Affecting Lake Water Quality

Section 4.3, above, describes the existing water quality conditions of Lake Merced. There are numerous processes and variables within the Lake that can affect water quality, particularly the extent and duration of seasonal stratification. These processes are described here as part of the setting for the analysis presented in Chapter 6 which describes the implications of the project on the ecology and health of the Lake.

As discussed in Section 4.2, Lake Merced Hydrology, the WSE of the Lake is lower than it has been in the past, primarily due to the loss of inflow from the historic watershed and groundwater extraction. The existing water quality conditions in Lake Merced for DO and pH are due in part to its current depth. Deep (greater than 300 feet) and very shallow (less than 3 feet) lakes rarely show any depletion of oxygen in the bottom waters. Lakes with depths between the two extremes are affected by the balance between wind mixing (which can stir oxygen down from the surface) and biological oxygen demand (BOD) from the decay of algae and other organic matter in the deep water and sediments. A second critical limnological factor affecting DO and pH is extended lake stratification that typically occurs between spring and fall. At this time, most of the mixing energy in the water is confined to the surface water layer and the deeper, cooler bottom water is relatively undisturbed. The critical depth at which extended stratification would occur is about 30 to 35 feet in the Bay Area climate. However, this depth is not within the range of lake depths possible for Lake Merced (Horne, 2012a).

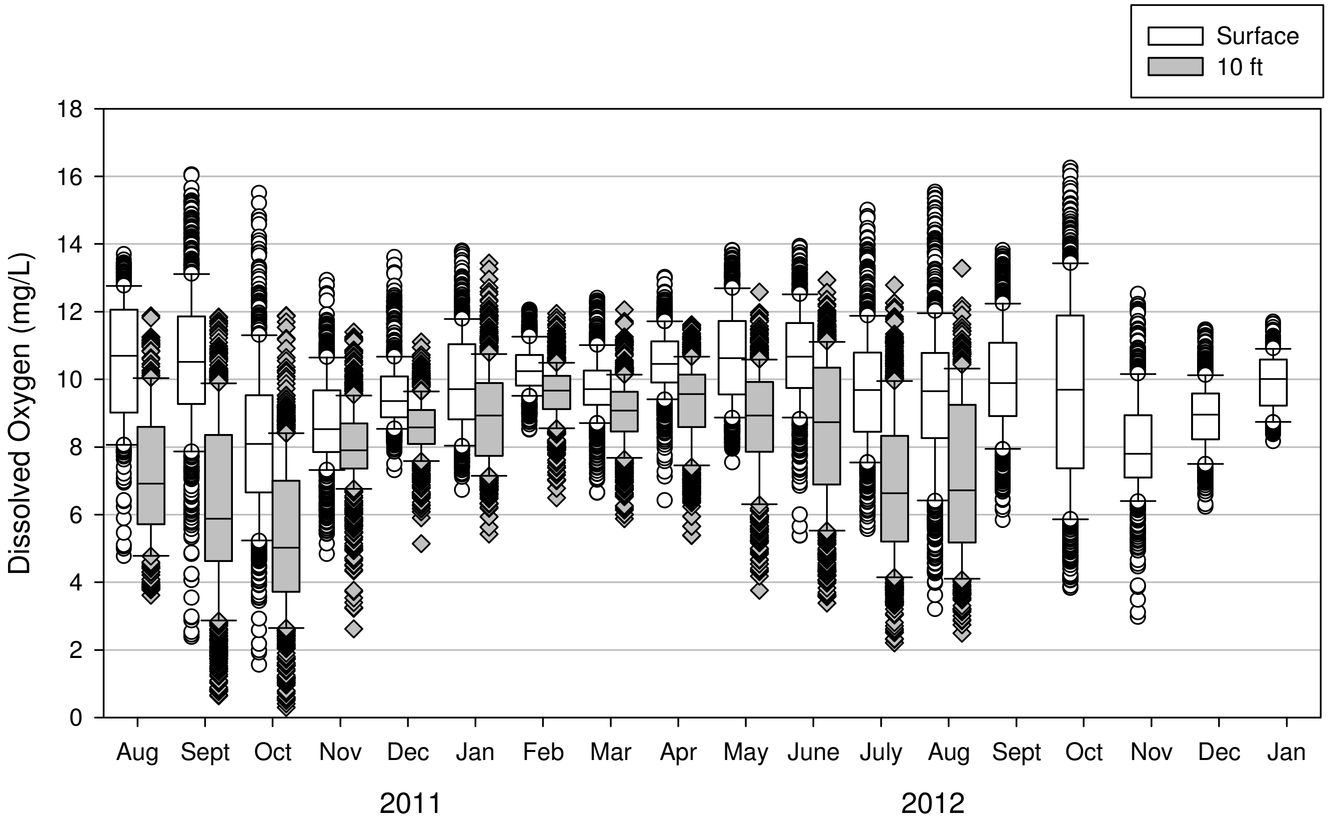


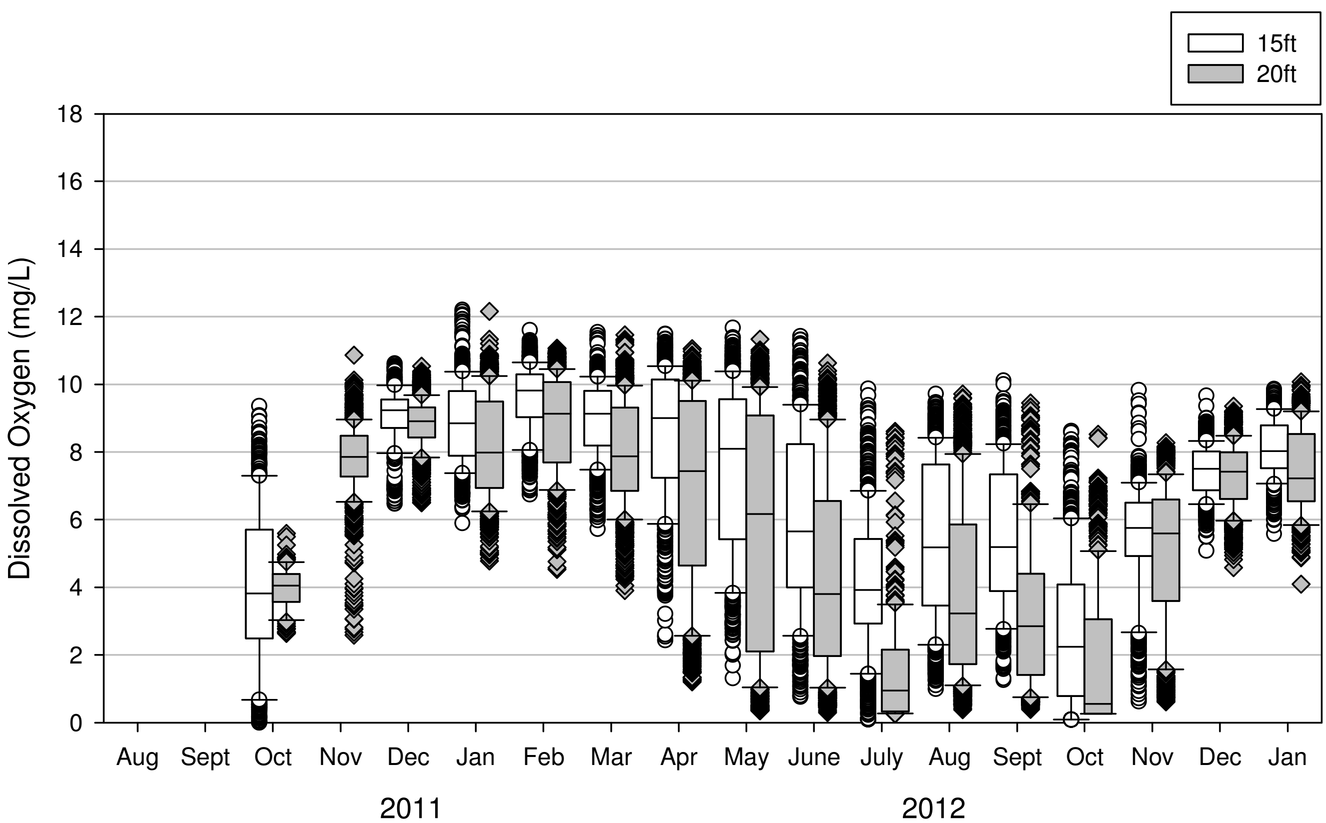


SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-11
Extended Monitoring Results for Temperature

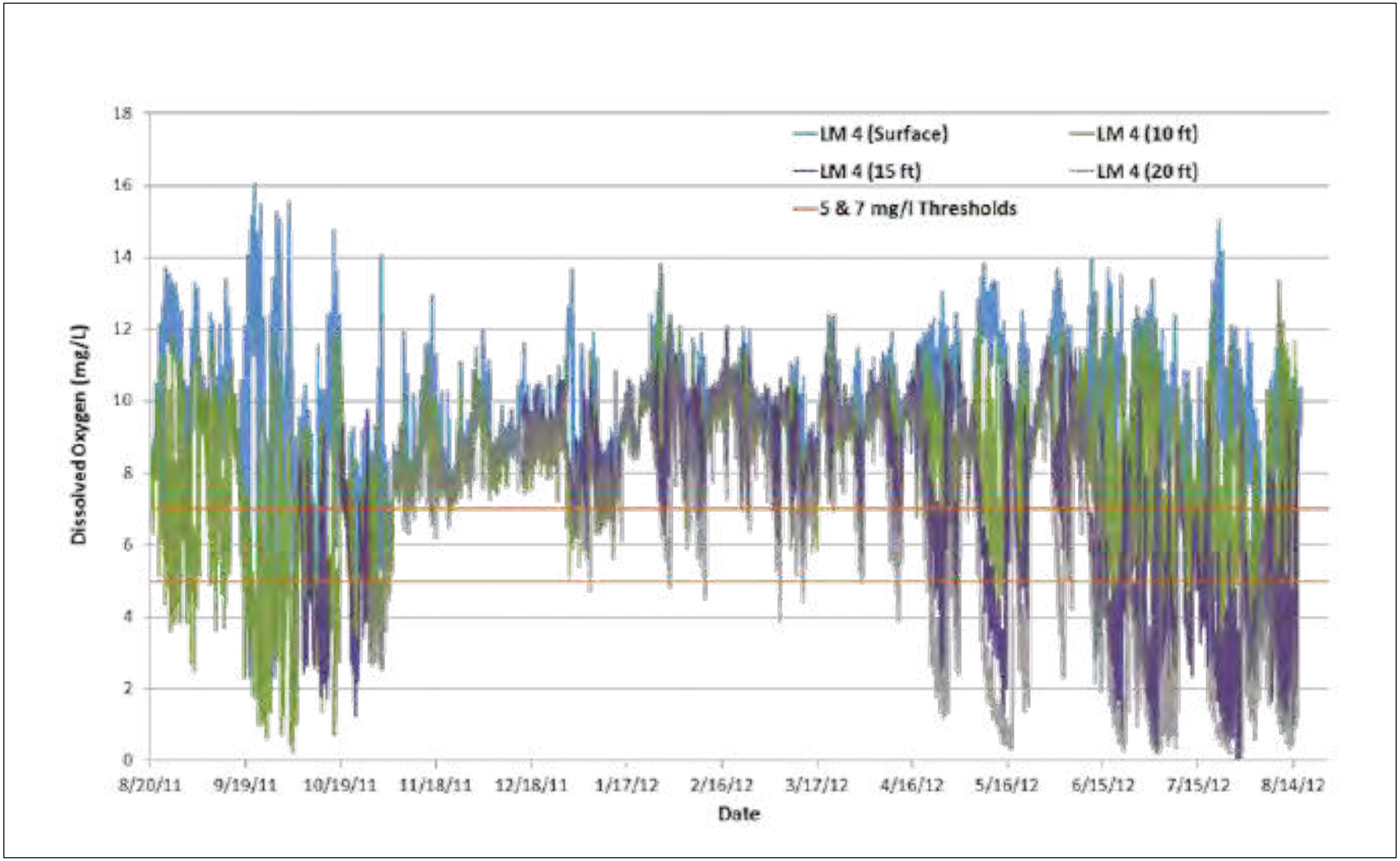




SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-12a
Extended Monitoring Results for DO

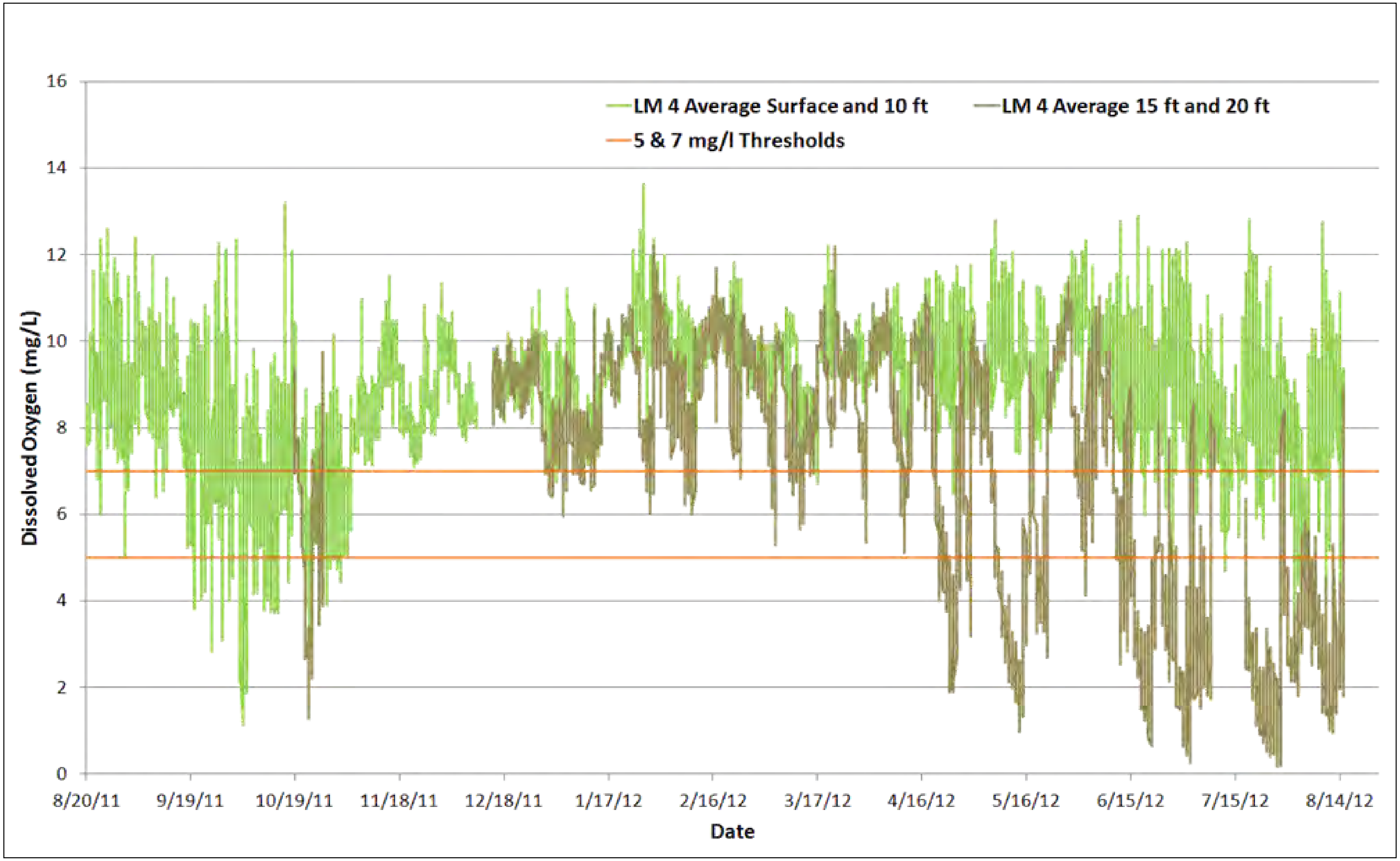


SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-12b

DO Summary by Depth (LM4)

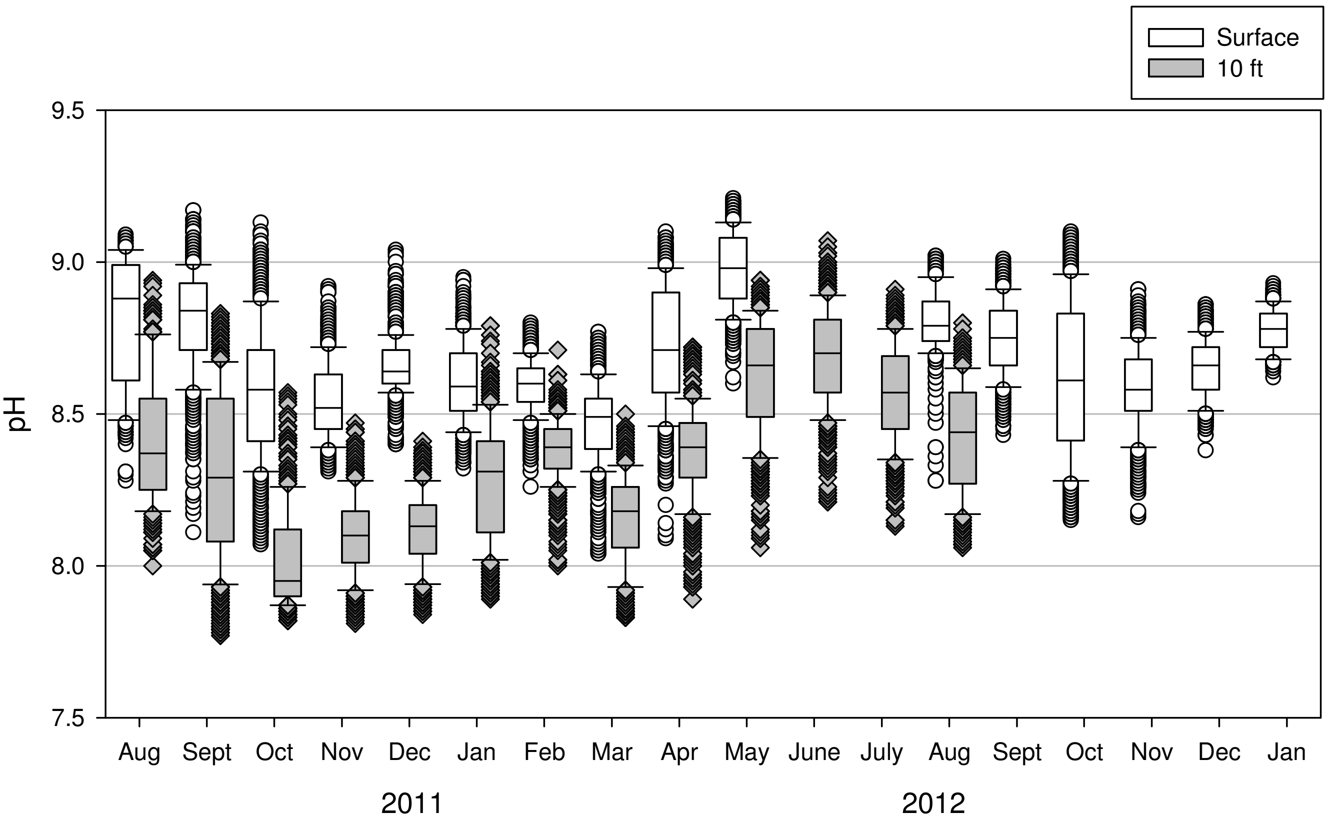


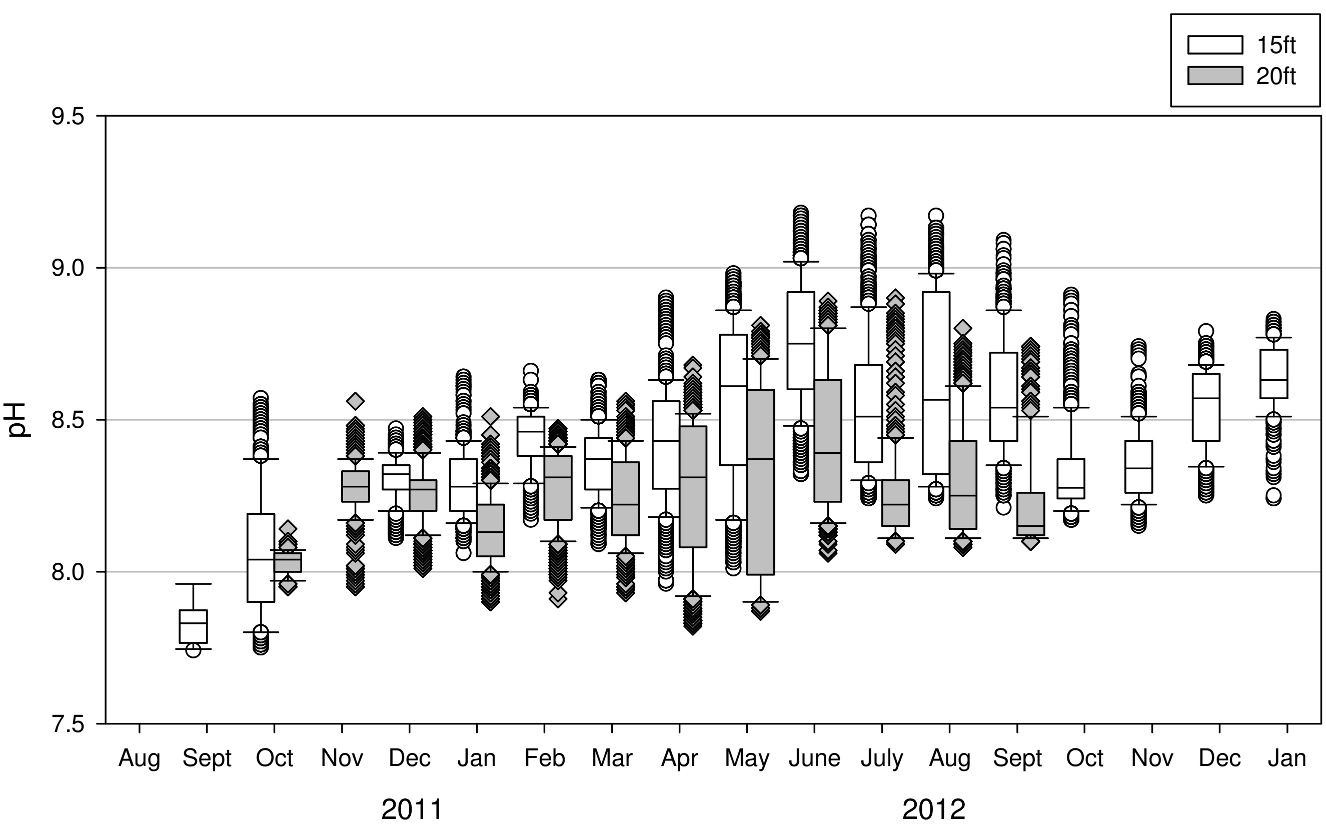
SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-12c

Upper and Lower Waters Average DO Summary

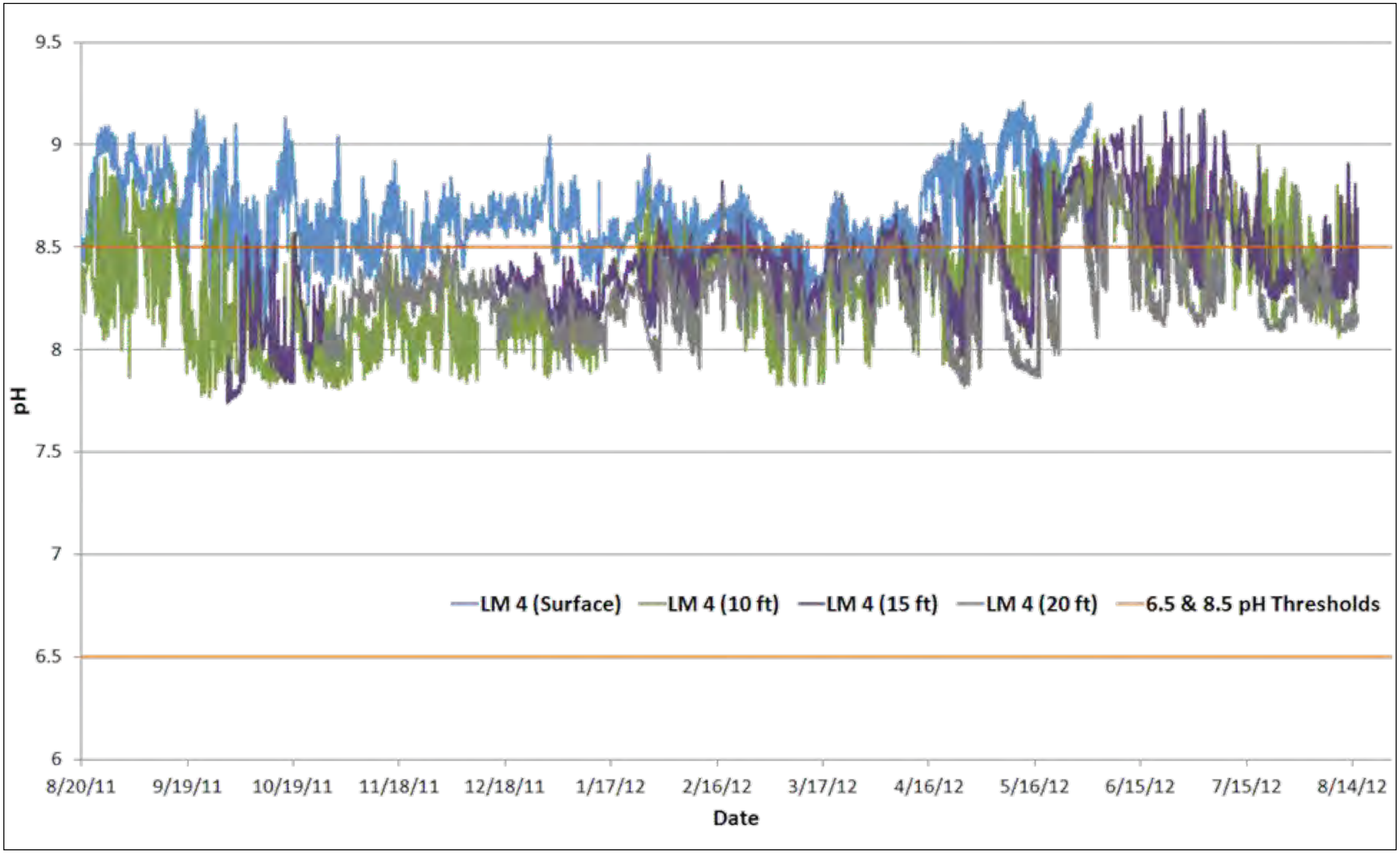




SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-13a
Extended Monitoring Results for pH

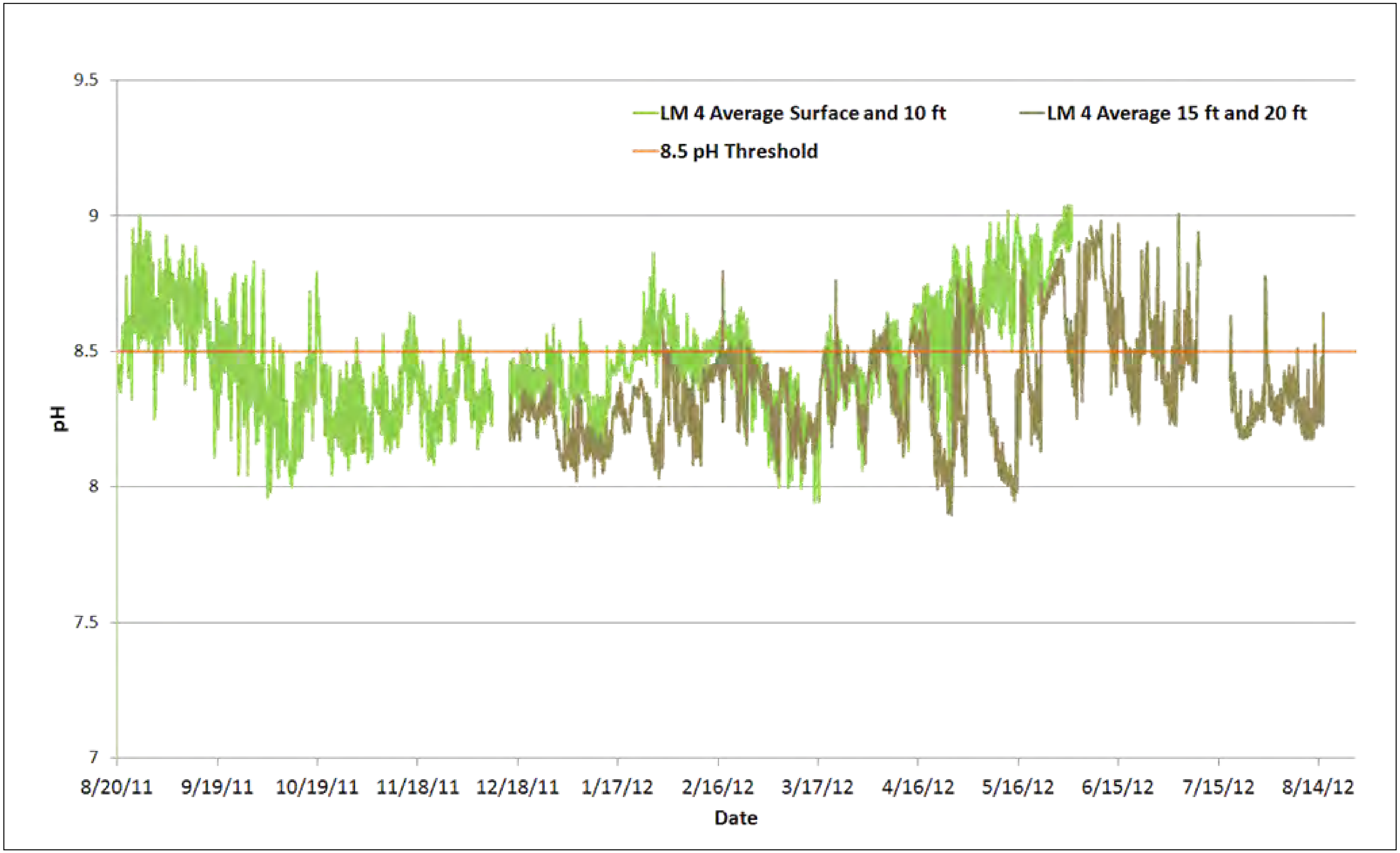


SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-13b

pH Summary by Depth (LM4)

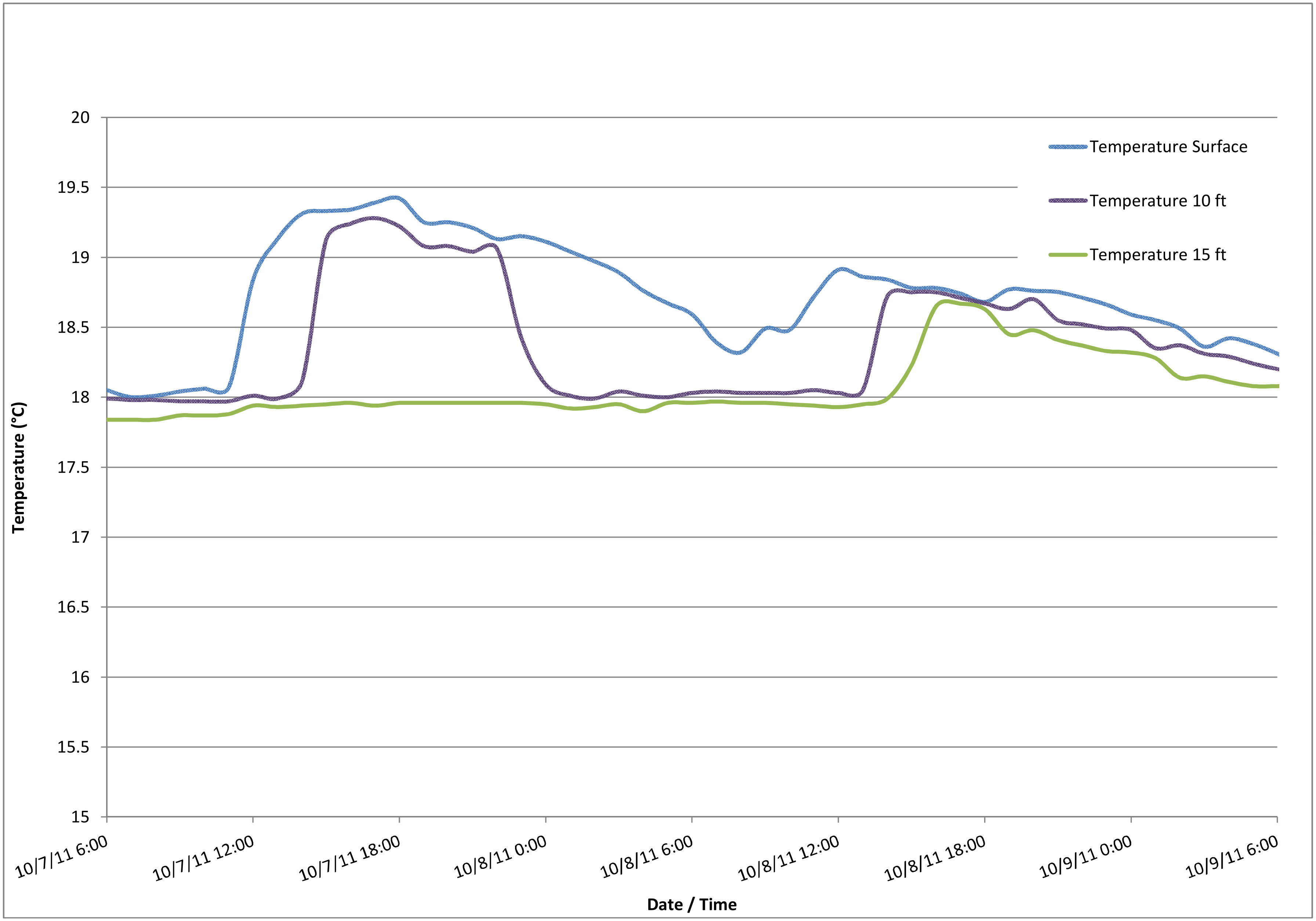


SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-13c

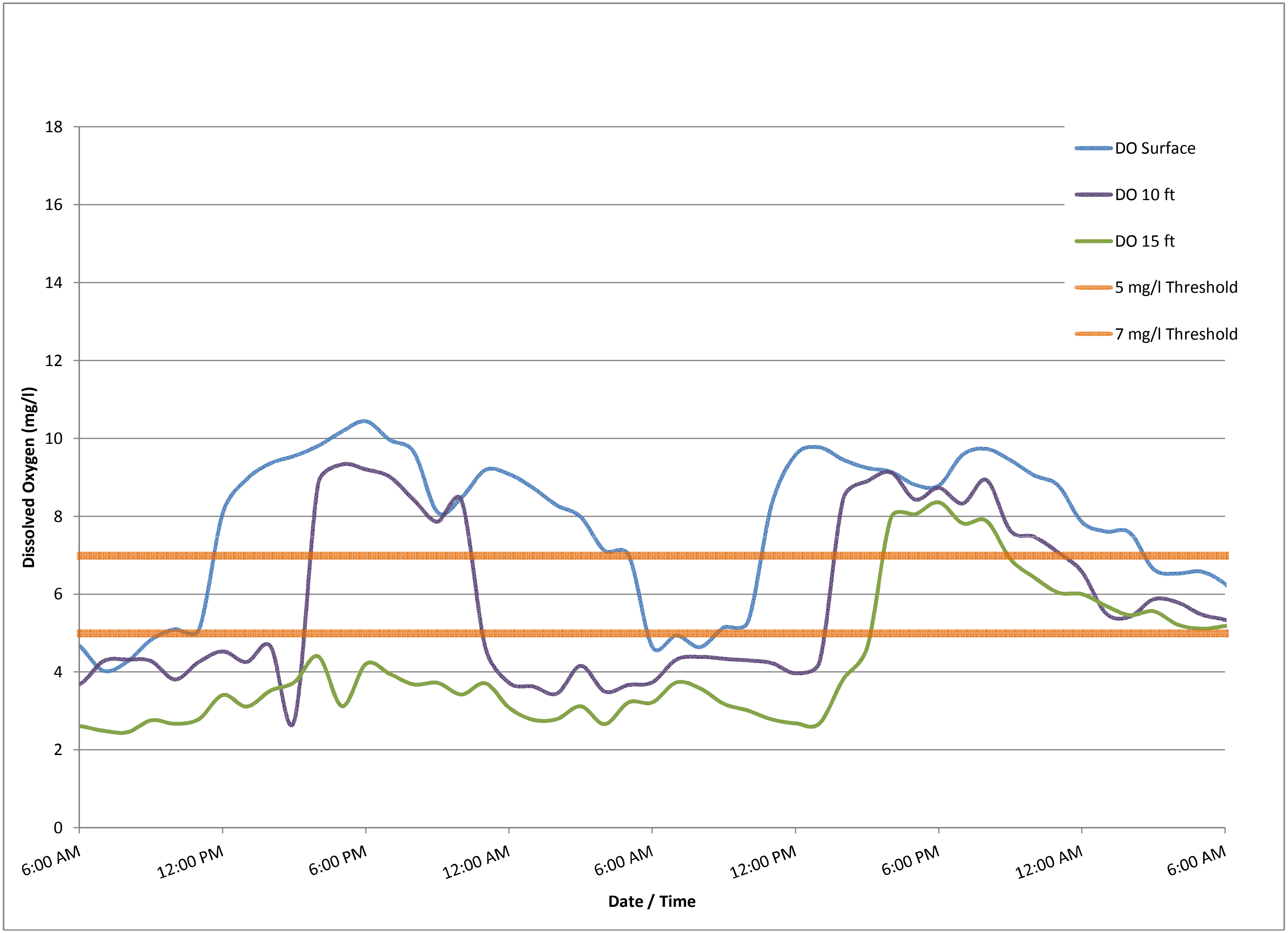
Upper and Lower Water Average pH Summary



Vista Grande Drainage Basin Improvement Project. 207036.01

SOURCE: ESA, 2013

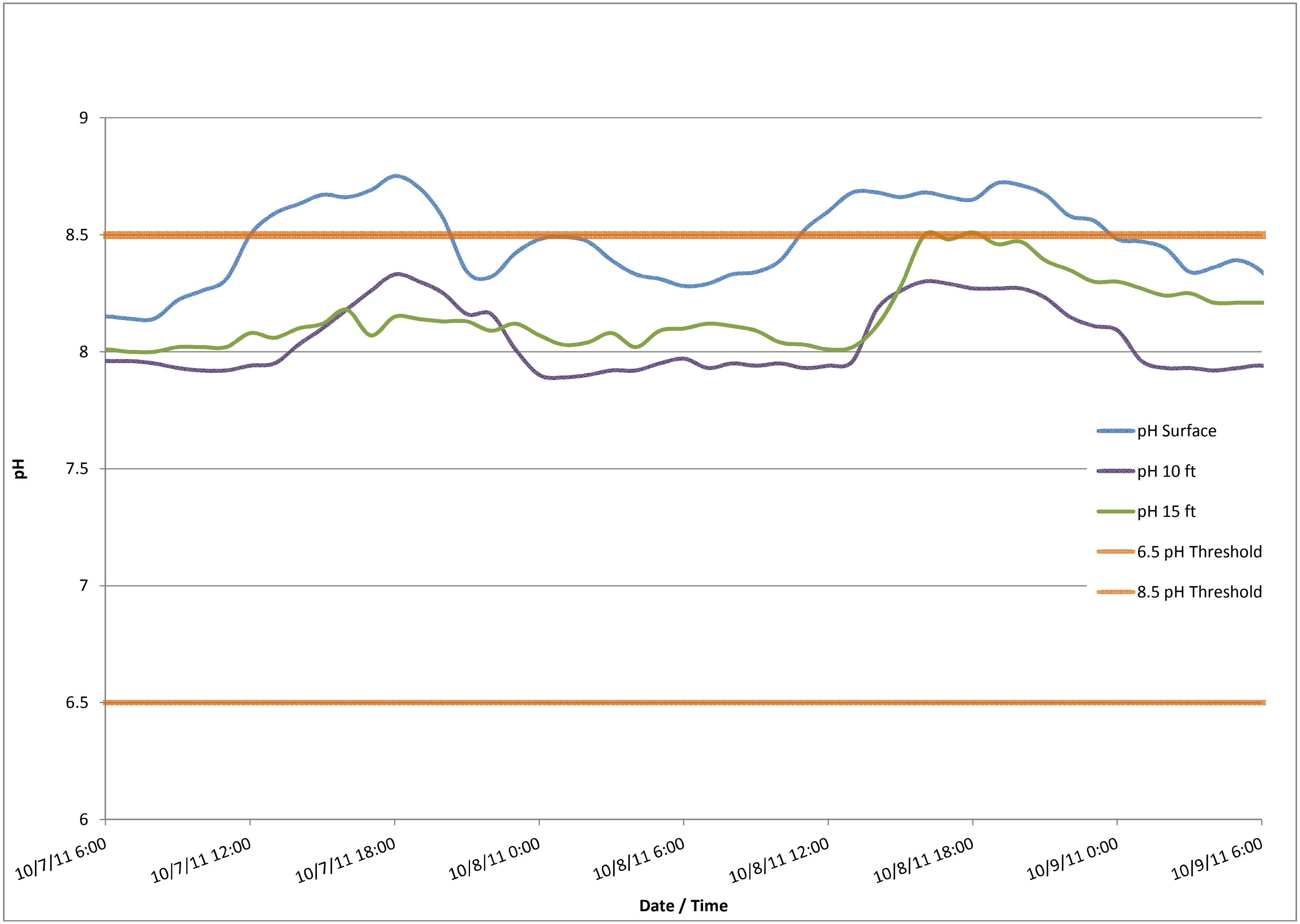
Figure 4-14
48-Hour Temperature Fluctuations



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-15
48-hour Dissolved Oxygen Fluctuations



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 4-16
48-hour pH Fluctuations

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The following sections outline these processes and provide a brief assessment of the current and historical trends for Lake Merced with respect to these processes.

4.4.1 Thermal and Chemical Stratification

A much deeper lake than Lake Merced would be thermally stratified from spring to fall (monomictic). Even if there were oxygen depletion in the deep water, the consequent release of nutrients from sediments would not reach the surface until the fall overturn when the available light is beginning to limit algal growth. South Lake currently has a maximum depth of approximately 24 feet, and is neither shallow enough to mix enough oxygen into bottom waters nor deep enough for nutrients to remain below the level of algal growth. Either deep, sustained thermal stratification or very shallow lake levels would result in less nutrient flux from sediments to surface water and in less eutrophication (fewer algae, more DO in deep water, and lower pH in the surface water).

More important to water quality than thermal stratification is chemical stratification, especially for DO. Chemical stratification is much less well understood than thermal stratification because it is a dynamic chemical-physical process while thermal stratification is primarily a physical process. In many lakes, thermal and chemical stratification occur together, but while thermal stratification is intermittent, chemical stratification is more persistent. The difference occurs because the rate of downward mixing of oxygen is less than the rate of oxygen demand of the sediments and deep water. Recent continuous recording probes in Lake Merced demonstrated weak thermal stratification but much stronger oxygen stratification.

Thermal stratification is the separation of water layers within a lake system, wherein warm, less dense surface waters (epilimnion) float over a deeper layer of cooler, denser waters (hypolimnion). Chemical stratification, shown by gradients of chemicals like oxygen and nutrients, often results after thermal stratification. Thermal stratification develops as surface water temperatures rise during spring and a vertical temperature gradient, or thermocline, develops. Bottom waters are then separated from the surface waters, due to the differences in water temperature and thus density. A lake may undergo periods of temporary weak stratification or may experience strong seasonal stratification that lasts from spring to late fall. The degree of variability is dependent on lake morphology and environmental conditions. Interpretations of historic (typically quarterly) monitoring data have generally suggested that Lake Merced tends to undergo weak intermittent thermal stratification (EDAW, 2004). More recent data collected using continuous (every one hour) recording probes in 2011-2012 confirm that stratification occurs and persists from mid-spring through late fall and that thermal mixing can occur every 9 to 11 days, depending on seasonal climatic and wind mixing conditions (see **Appendices C-1** and **C-4**).

Thermal stratification has important water quality implications because of its influence on DO levels, nutrient dynamics, and habitat quality for fish and other aquatic organisms. In eutrophic lakes with large algal populations, stratification can have significant effects on pH and DO levels in the separated surface and bottom waters. As indicated by Secchi disk readings, sufficient sunlight for algal growth only penetrates about 4.6 feet (approximately 2.3 times Secchi depth) in South Lake. Algal photosynthesis is therefore primarily limited to this shallow photic zone. In a

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water column that is mixing, algae growth is limited by the amount of sunlight available to phytoplankton cells. The availability of sunlight (irradiance) is a function of the ratio between the euphotic depth (z_{eu}) and the depth of mixing (z_{mix}). If z_{eu} equals z_{mix} (i.e., $z_{eu}/z_{mix} = 1$), then the cells are constantly illuminated and photosynthesis is continuous and maximized during the daylight period. In Lake Merced, the photic zone is a fraction of the mixed epilimnion zone with a z_{eu}/z_{mix} ratio of about 1:2. The ratio indicates that the algae present in the Lake are most growth limited by access to light and not nutrients, since half of the algae spend the daylight hours mixed down into the darker deeper water with limited available light for growth.

During photosynthesis, algae take in carbon dioxide from the water to produce organic (carbon-based) matter, and in the process produce and release oxygen. During intense photosynthesis, the imbalance between instantaneous uptake of carbon dioxide and its resupply from the air or the dissolved carbonate pool causes the pH to rise. There are sufficient algae levels in Lake Merced (chlorophyll a is approximately 26 to 30 μg/L) to produce intense photosynthesis in surface waters. This is why the surface waters in the Lake show both elevated pH and DO levels compared to deeper water. The effect is most pronounced on calm, sunny days when the upper few feet of the Lake become unusually warm and stable. Under more normal conditions, afternoon winds stir the upper waters, resulting in elevated pH through much of the epilimnion.

Conversely, in the cooler, denser bottom waters (hypolimnion), separated from the warmer, less dense and mixed surface waters, pH and DO levels are lower. No photosynthesis occurs below the photic zone; therefore, there is no photosynthesis-driven increase in pH. The waters below 10 to 15 feet in depth remain partially or totally isolated from the surface and from potential reaeration via diffusion and wind mixing. Algal respiration depletes the available oxygen and produces carbon dioxide, reducing pH in deep waters. Possibly more important relative to contributing to low DO conditions is the oxygen demand from the decay of organic matter in the bottom sediments. These factors can combine to reduce bottom DO levels to near zero for periods of time until the stratification breaks down and the Lake mixes again.

For Lake Merced, data collected from August to October in 2011 show that complete mixing of the water column (top to bottom) occurred on average every 9 to 11 days[8] (see Figure 4-9). Dr. Horne confirmed the representativeness of this mixing frequency range based on additional 2012 data (Appendix E). The rate of mixing in summer-fall 2011 was usually insufficient to carry enough oxygen down to offset the BOD of the sediments created by organic matter decay. Complete holomixis (top-to-bottom mixing) probably occurred only once in summer-fall 2011 (see Figure 4-9). The result was an extended period of low DO in the deeper waters.

The following sections describe variables that may influence the degree and extent of stratification in Lake Merced.

8 Data collection began in August 2011 and continued through January 2013.

Temperature and Season

Lake Merced has an atypical temperature regime for its latitude. During warm periods from spring through fall, rising air temperature and solar radiation initiates stratification by warming the surface layers of a lake. In many U.S. lakes located away from cool ocean water, stratification occurs easily since summer air temperatures typically reach 27 to 32 °C (80 to 90 °F). However, in general, San Francisco is characterized by much cooler air temperatures, with summer temperatures ranging from an average low of 11 °C (52 °F) to an average high of 22 °C (71 °F) in the summer. In addition, the coastal marine layer tends to persist throughout much of the day, reducing incoming solar radiation.

These cool weather patterns tend to minimize the warming of Lake Merced and reduce the potential for long-term stratification. Average yearly surface temperatures are approximately 16 °C (61 °F) (SFPUC, 2009). However, during periods of warmer weather, which tend to occur in the late summer and early fall, the Lake may undergo short-term warming. For example, in South Lake, average surface temperatures during the winter months are approximately 12 °C (54 °F), while average surface temperatures in the summer are 19. 4 °C (67 °F). During these warm periods, higher surface temperatures can contribute to weak, temporary thermal stratification within the Lake (EDAW, 2004; SFPUC 2009; ESA 2011-2012 monitoring data). However, given the high rate of decomposition of algae and other accumulated organic matter at the bottom of the Lake, chemical stratification may persist for longer than classical thermal stratification.

Wind

Wind provides one of the main mixing forces that can disrupt stratification patterns in a lake. A lake consists of layers or slabs of water, each of which is slightly different in temperature and thus density. Light breezes do not have sufficient energy to lift tons of water in slabs at a deeper depth, so only strong winds have much effect. The wind pushes the surface slab horizontally around the lake. The motion of this upper layer creates a shear force between the uppermost water layer and the layer below, causing friction and a small amount of vertical mixing. When the wind is strong, surface waves occur and create several forces that increase vertical mixing. Waves cause vertical oscillations of water that are transmitted down through the slabs to the lake bed. Wave height and vertical water oscillations depend mostly on wind strength. However, the transmission of motion from surface waves (wave height) decreases logarithmically with depth depending on wavelength (long-wavelength waves stir deeper). In turn, wavelength depends on fetch, the distance over which the wind blows. Because Lake Merced is small, even strong winds create small wavelengths that do not cause deep mixing. Indeed, data collected in 2011 showed that complete mixing only occurred on average every 9 to 11 days, depending on the site in the Lake.

In fairly shallow and cool lakes like Lake Merced, the water column may seem to be well mixed as shown by temperature (EDAW, 2004; ESA 2011 data), but still shows chemical stratification with low DO and pH at the bottom and higher DO and pH at the surface. This is because although the lake is mixing, the rate of mixing and transport of chemicals from surface to bottom is too slow to overcome the rate of biological reactions like photosynthesis and respiration described above. There are not enough windy days to keep Lake Merced chemically mixed even though top and bottom temperatures are fairly similar.

Depth

The depth of a lake influences the degree of interaction between the surface and bottom layers. In shallow lakes, wind mixing is usually strong enough to mix a lake from top to bottom and prevent stratification. Deeper lakes tend to exhibit stronger patterns of stratification because there is less interaction between the surface and bottom. With depths ranging from 2 to 24 feet, Lake Merced is classified as a shallow lake. Therefore, wind induced mixing within the water column usually prevents development of strong, persistent thermal stratification. However, there is sufficient depth in the deeper waters to allow persistent chemical (DO) stratification, given the eutrophic nature of the Lake and the high rates of algal growth and sediment organic matter decomposition.

Water Clarity

The clarity of lake water is perhaps the most important and visible water quality parameter to the public. Water clarity can be measured by noting the depth to which a white disc (Secchi disc) can be seen. Secchi depths range from a few inches in very eutrophic lakes with algae scums to over 100 feet in very clear blue lakes like Lake Tahoe. In Lake Merced, there appear to be two mechanisms that decrease light penetration into the water: suspended inorganic sediments and algae. Light absorption by water is reduced by algae (chlorophyll) and is related in the model used for the water quality analysis (described in Chapter 6) to water clarity (described in detail in **Appendix E**). Water clarity due to sediment is also considered in the model used for the water quality analysis. Based upon these measures, Lake Merced has limited water clarity (2 feet) but has seen a recent small increase in water clarity potentially due to improvements in the adjacent San Francisco watershed sediment control measures. The change could also be due to the additional few feet of water added (decreased mixing) or increases in shoreline submerged vegetation (reduces wave-generated sediment suspension).

The photic zone or layer where the light intensity is suitable for photosynthesis can be defined as that greater than 1 percent of incident light. By convention, the zone below 1 percent of incident surface light is deemed too dark for photosynthesis (Horne and Goldman, 1994) and is called the aphotic zone. The photic zone depth is not known for Lake Merced but can be approximated as 2.3 times the Secchi depth (2 feet) and is thus 4.6 feet. Algae would grow well in the upper 3 to 6 feet of water in the Lake. However, almost 80 percent of the Lake water column of 24 feet is below the photic zone and is too dark for algae growth. The Lake mixes fully every 9 to 11 days and probably down to about half way (10 to 13 feet) every windy afternoon. Thus, the algae would spend much of the daylight hours in the dark with reduced efficiency of growth. This is likely the reason that there are not more algae in Lake Merced. If the Lake did not mix in this manner or was shallow enough for mixing only in the photic zone, chlorophyll levels would likely be higher.

4.4.2 Nutrient Enrichment

Nutrient dynamics are important to water quality, as high concentrations of nutrients can lead to eutrophication. The degree of algal growth is usually restricted by the amount of the most limiting nutrient, which in aquatic systems is usually nitrogen or phosphorus. The limiting nutrient in some systems can be determined by looking at the ratio of nitrogen to phosphorus. However, in eutrophic systems when concentrations of both these nutrients are high, algal biomass may become so large that available light for photosynthesis becomes the limiting factor (Pepper et al., 2006).

There have been several water quality reviews and assessments conducted for Lake Merced over the past 10 years. (See **Appendix F**, Inventory of Documents Related to Lake Merced and Vista Grande Watershed Water Quality. See also Section 4.3, Lake Merced Water Quality.) In general, nutrient concentrations within Lake Merced are in the range of eutrophic systems, as evidenced by Secchi depths that average less than 2 feet. Over the time period of 1997 to 2009, the average total phosphorus (TP) concentration was 149 µg/L, the average orthophosphate concentration was 61 µg/L, the average ammonia concentration was 5 µg/L, the average nitrate concentration was 31 µg/L, and total Kjeldahl nitrogen (TKN) was 3670 µg/L (SFPUC, 2009). As shown in **Table 4-4**, nutrient concentrations in South Lake are indicative of a eutrophic lake, based on trophic state indices and models.

TABLE 4-4
COMPARISON OF SOUTH LAKE NUTRIENT CONCENTRATIONS TO TROPHIC STATE INDICATORS

Water Quality Variable	Average Measurement in South Lake[a]	Trophic State Boundary Level		Predicted Trophic State for South Lake
		Cooke et al.	Horne	
Total Phosphorus (TP)	149 (µg/L)	>28 (µg/L) Mesotrophic >100 (µg/L) Hyper-eutrophic	> 32 (µg/L) Eutrophic	Strongly Eutrophic
Total Inorganic Nitrogen (TIN) (nitrate + ammonium)	81 (µg/L)	Not Considered	> 110 (µg/L) Eutrophic	Eutrophic
Secchi depth	1.8 feet	< 2 m (6.6 ft) Eutrophic < 1 m (3.3 ft) Hyper-eutrophic	< 2.6 m (8.5 ft) Eutrophic	Strongly Eutrophic
Chlorophyll a	26 (µg/L)	> 9 (µg/L) Eutrophic > 25 (µg/L) Hyper-eutrophic	> 7.9 (µg/L) Eutrophic	Strongly Eutrophic

NOTE:
[a] Average from 1997 to 2009

SOURCE: SFPUC, 2010; Cooke et al. 2011; Horne, 1996

Conclusions regarding nutrient limitation within the Lake have varied over time, depending on report authors, and on the methodology used for making the determination. In 2004, EDAW analyzed nutrient levels at Lake Merced and found that based on the total nitrogen (TN) to TP ratio it appeared that Lake Merced may have been phosphorus-limited. However, when the nitrogen to phosphorus ratio was analyzed based on the bioavailable inorganic nutrients (nitrate, ammonia, and orthophosphate), instead of TKN (which includes the minimally biologically available organic nitrogen fraction that tends to dominate in the Lake), along with nitrate and TP, EDAW determined that the Lake would appear to be co-limited by nitrogen and phosphorous (EDAW, 2004).

In 2007, RMC performed an analysis of nutrient levels at Lake Merced and, using the bioavailable forms of nitrogen and phosphorus (NH3-N + NO3-N:Ortho P), found the Lake to be strongly nitrogen-limited (RMC, 2007). Kennedy/Jenks Consultants (2010), using TN (TKN + nitrate) and 100 percent of TP to calculate the nitrogen to phosphorus ratio, estimated that the Lake has been nitrogen-limited since 2005. Since Lake Merced has high levels of organic nitrogen, it is more appropriate to analyze the bioavailable nitrogen to bioavailable phosphorus ratio. This is because algae can uptake the inorganic forms of nitrogen more easily. Bioavailable nitrogen is the sum of nitrate and ammonia, which is referred to as total inorganic nitrogen (TIN). Bioavailable phosphorus has been estimated at approximately 80 percent of total phosphorus. Using the TIN: 0.8 TP ratio as the limiting nutrient indicator, RMC concluded that the Lake was strongly nitrogen-limited and had been since 2000 (RMC, 2007).

The debate over whether nitrogen and/or phosphorus may be the more limiting nutrient is somewhat academic given that the rate of supply of nutrients present has been more than sufficient to render the Lake eutrophic (Table 4-4) and to support relatively high concentrations of algae year-round in Lake Merced. Although over a dozen algal species have been identified in Lake Merced, the four most prominent are *Oscillatoria*, *Anabaena*, *Melosira*, and *Mougotia*. *Oscillatoria* and *Anabaena* are cyanobacteria (blue-green algae) that have the unique advantage of being able to control their buoyancy and thus their position in the water column, optimizing exposure to sunlight and available nutrients. *Anabaena* has the additional ability to fix nitrogen (N+), giving it a distinct advantage should inorganic forms of nitrogen (NO_3 - and NH_4 +) become limited. *Melosira* is a diatom, while *Mougotia* is a green algae. *Oscillatoria* is the dominant phytoplankton species in both North and South Lakes with *Oscillatoria* plankton counts two to three orders of magnitude greater than the other species (Merritt Smith Consulting, 2001).

All of the prominent algae species are characteristic of eutrophic waters. The various trophic status indicators also indicate the presence of eutrophic conditions in Lake Merced. Although both *Oscillatoria* and *Anabaena* contain gas vacuoles which allow them to regulate depth in the water column by raising or lowering cell density (Merritt Smith Consulting, 2001), only *Anabaena* is large enough for this to play a potentially important role in Lake Merced. The regulation of sinking and rising is controlled by the gas vacuoles, but more so by the colony size.

The small single filaments of *Oscillatoria* are easily stirred lower in the water column depth by the wind-driven mixing and rise only slowly in calm periods. Thus, this genus is ideally suited for the weakly stratified conditions of Lake Merced, provided that the supply of nutrients is adequate. *Oscillatoria* is common in similar cool-water, nutrient-rich shallow lakes in many places in the world.

External Nutrient Sources

Potential external sources of nutrient inputs to Lake Merced include watershed sources from the portion of the Lake Merced watershed located within San Francisco discharged to the Lake via stormwater runoff and authorized non-stormwater sources, groundwater infiltration, atmospheric deposition, and algal biological nitrogen fixation.

Areas within the watershed that are potential non-point sources of nutrients to Lake Merced include Harding Park Golf Course, adjacent roadways, surrounding open space areas, and occasional peak wet weather overflows from the Canal. In the past, Harding Park Golf Course used a complete fertilizer (containing nitrogen, phosphorus, and potassium) at an application rate of 6 pounds (lbs) of nitrogen per 1000 square feet (ft^2) (260 lb/acre). This rate of nitrogen application is likely to have contributed to the lake's nitrogen store in the past as others have surmised (see below). In addition, soil nitrogen buildup can last for many years, despite the loss of soluble nitrogen to groundwater. Phosphorus is no longer applied to golf course turf areas and up to 95 percent of stormwater from the golf course now drains to a basin under the driving range (EDAW, 2004; SFPUC, 2011a). However, it is possible that past runoff could have contributed to buildup of nutrients in lake sediments (EDAW, 2004). Certain areas of groundwater within the Westside basin have high levels of nitrate that may infiltrate into Lake Merced (SFPUC, 2011a; EDAW, 2004).

Internal Nutrient Sources

Internal sources of nutrients in Lake Merced include sediments and decomposition of deposited organic matter. Bottom sediments in lakes can be a large reservoir for nutrient storage. Under aerobic conditions, an oxidized surface layer forms on the sediment acting to retain nutrients. However, under anoxic conditions created during periods of stratification or low mixing rates, nutrients may be released from sediments into the water column, contributing to eutrophication. The degree of nutrient release is dependent upon lake conditions. Warmer water promotes more internal loading of nutrients, and longer periods of anoxia contribute more than short ones.

Nutrient Removal

Nitrogen in aquatic systems may exist in several forms: dissolved nitrogen gas (N_2), organic nitrogen incorporated into organic matter, ionized (NH_4+) and un-dissociated ammonia (NH_4OH), dissolved ammonia gas (NH_3), nitrite ion (NO_2-), and nitrate ion (NO_3-). Under aerobic conditions, bacteria mediate the oxidation of ammonia to nitrate (with an intermediate step as nitrite) in a process called nitrification. In the nitrification reaction, 1.0 gram (g) of ammonia consumes 4.57 g of oxygen. In the absence of oxygen, bacteria mediate the reduction of nitrate to nitrogen gas in the process of denitrification (Merritt Smith Consulting, 2001). Since denitrification is a microbial mediated process, it slows at cold temperatures.

Denitrification is a process where additional ammonia and/or nitrate added to the lake would be removed from the system to the atmosphere and therefore not be available to support additional algal (or other aquatic plant) growth. However, under most lake conditions, nitrate is present in very low concentrations near the anoxic sediments so that denitrification rates are very low. Artificial lake mixing can increase movement of nitrate from the free water to the sediment zone and increase denitrification. Phosphorus is typically adsorbed onto particulates (sediments) and may therefore be removed via sedimentation of the associated particulate in addition to uptake by aquatic plants. However, upon decay of the plants or organic particles, phosphate is once again released to the water.

Nutrient removal processes, such as denitrification or organic matter losses to deep (biologically unavailable) sediments, are difficult to quantify. The nutrient related analyses in this WQA (Chapter 6) conservatively assume that nutrient inputs into the Lake remain bioavailable.

4.5 Relationship between Water Mixing, Nutrients and Algae

The average annual nutrient concentrations in Lake Merced (Table 4-4) are similar to many urban waters in the semi-arid West. Biologically available nitrogen is scarce (mean TIN = 81 µg/L) and biologically available phosphorus is plentiful (mean TP = 149 µg/L). Nitrate and ammonia are readily used by algae but organic nitrogen (most of TN here) is refractory (hard to biologically break down) and therefore mostly unavailable for algae growth. In contrast, about 80 percent of total phosphorus can be easily converted to biologically available phosphate within hours by the common alkaline phosphatase enzymes present in algae and sometimes in the free water. The enzyme cleaves the phosphate-carbon bond. Organic nitrogen can also be converted to ammonia but there is no abundant equivalent enzyme to break the carbon-amine bond of nitrogen. The mineralization of most organic nitrogen to bioavailable TIN takes months or years and is far too slow to supply algae blooms that grow in a few days or weeks. Given the very low amounts of bioavailable nitrogen present, limitation of algal growth by TIN is possible. Algal concentrations, as evidenced by chlorophyll a levels, are generally not present in densities that would limit growth by self-shading, although during deep mixing events, growth may be light-limited because some algae would be too deep for sunlight to reach.

Thus, the available evidence indicates that the shortage of bioavailable nitrogen (TIN) most likely limits algal growth in Lake Merced unless there are so many algae and/or sediments present that light is the growth limiting factor. At the end of the spring bloom of algae, nutrients are depleted and the only sizable new source is via mixing from the sediments to the surface water. During the spring-fall period, data from the in-situ probes can be used to estimate top-to-bottom mixing (holomixis) in the Lake. A value of mixing every 9 to 11 days was found (Figure 4-8, Appendices C-1 and C-4). Thus, approximately every week and a half, the surface water nutrients can be replenished to some extent by deep water nutrients.

4.6 Biological Resources

This section describes the history and condition of Lake Merced's aquatic life biological resources relative to the protection of RWQCB Basin Plan beneficial uses, based on the indicator water quality objectives of DO, pH, and temperature. This discussion focuses on fisheries resources and fisheries habitat since wetland and riparian habitat and special-status bird species are likely to be more sensitive to water level changes, rather than potential lake level related water quality changes.

4.6.1 Existing Fisheries Resources and Habitat

Fisheries Resources

Throughout its history, including the establishment of a recreational fishery, Lake Merced has undergone a number of changes in fish species composition due to changes in surrounding land use and vigorous management of its fisheries resources (EDAW, 2004). As described previously, Lake Merced was once a coastal lagoon connected to the Pacific Ocean and likely supported native fish with wide salinity tolerances, including possibly the now endangered tidewater goby (*Eucyclogobius newberryi*). Although the total number of species known to have occurred in Lake Merced at one time or another varies somewhat among the authors of prior assessments, EDAW (2004) summarized confirmed species observations from sporadic sampling efforts over the period of 1939 through 1989 (**Table 4-5**). Of these, only seven were observed by Maristics in 2004 (Maristics, 2007).

TABLE 4-5
CONFIRMED FISH SPECIES OCCURRENCES IN LAKE MERCED

Common Name	Scientific Name	Native?	Present in 2004?
Rainbow trout	*Oncorhynchus mykiss*	x	x
Kokanee	*Oncorhynchus nerka*	x	
Brook trout	*Salvelinus fontinalis*		
Brown trout	*Salmo trutta*		
Sacramento sucker	*Catostomus occidenotalis*	x	
Hitch	*Lavinoia exilicauda*	x	
Sacramento blackfish	*Orthodono microlepidotus*	x	x
Hardhead	*Mylopharodono conoocephalus*	x	
Tule perch	*Hysterocarpus traskii*	x	x
Prickly sculpin	*Cottus asper*	x	x
Threespine stickleback	*Gasterosteus aculeatus*	x	
Largemouth bass	*Micropterus salmoides*		x
Green sunfish	*Lepomis cyanoellus*		
Bluegill	*Lepomis macrochirus*		
Channel catfish	*Ictalurus punoctatus*		
White catfish	*Ameiurus catus*		x
Brown bullhead	*Ameiurus noebulosus*		
Black bullhead	*Ameiurus melas*		
Goldfish	*Carassius auratus*		
Common carp	*Cyprinous carpio*		x

SOURCE: EDAW, 2004; Maristics, Inc., 2007.

Based on the results of 2004 seining surveys, the Lake Merced fish assemblage is currently dominated by largemouth bass, Sacramento blackfish, and rainbow trout, while tule perch, common carp, and smaller native species such as sculpins are also present (Maristics, 2007). Many of the native species in Lake Merced are also present as a result of human-mediated introductions. Since much of the interest in Lake Merced is in recreational fishing, this analysis focuses on specific species. Maristics (2007) conducted creel surveys (i.e., angler polling) and determined that four species represented over 95 percent of the fish specifically targeted by anglers at Lake Merced. These are, in order of most frequently targeted by anglers, rainbow trout (48.3 percent targeted), largemouth bass (20.7 percent), common carp (19.5 percent), and channel catfish (6.9 percent). These species were therefore selected to be considered in this analysis. However, as described below, the habitat requirements among these species are quite different and the fish assemblage in Lake Merced would not occur naturally, only existing here due to decades of intensive management for recreational fishing. This presents a unique challenge regarding the application of WQOs for the protection of beneficial uses relating to a fisheries community whose species composition would not occur naturally.

Rainbow Trout

Based on creel surveys conducted at Lake Merced in 2004 and 2005, rainbow trout are the species most frequently targeted by local anglers (Maristics, 2007). Rainbow trout are native to California, but not to Lake Merced. They are essentially a freshwater stream-dwelling species requiring flowing water over gravel substrates for successful spawning. Although some rainbow trout populations occur naturally in lakes, such systems that have a self-sustaining population provide a range of habitat types to support the requirements of the full species life-cycle. Adults migrate into tributary streams with suitable riffle habitat to spawn, and juveniles may subsequently migrate downstream to the lake to grow and mature following emergence and early life-stage rearing in stream habitat. Since Lake Merced has no tributaries with suitable reproductive habitat for trout, the existing population is not self-sustaining and is maintained entirely through a relatively extensive California Department of Fish and Wildlife (CDFW, formerly California Department of Fish and Game) stocking program. Because habitat supporting the migratory, spawning, and early life-stage requirements of rainbow trout is entirely absent in Lake Merced, the only life-cycle stage Lake Merced supports is the juvenile and adult rearing life stage. Therefore, the following discussion focuses on the relevant habitat requirements and tolerance ranges for rearing juvenile and adult rainbow trout within the context of existing conditions in Lake Merced related to key water quality parameters.

Lake habitat quality for rainbow trout is primarily driven by temperature, DO, and food availability.

Lakes and reservoirs in California are typically temperature stratified during the summer and fall seasons, with surface waters that are too warm for trout. Deeper waters are colder but often have depleted levels of DO that are insufficient to support trout. Suitable habitat for trout in lakes and reservoirs during the summer and fall season is typically limited to a thin zone at intermediate depths that is sufficiently cool for trout but is not too depleted in DO. In typical California rainbow trout habitat, water temperature varies over the course of a day and seasonally, following changes in air temperature and solar radiation. Fluctuating diurnal water temperatures can aid in survivability of salmonids (Busby et al., 1996*)*. Rainbow trout may utilize habitat with potentially stressful DO levels for short periods as a refuge from high temperature areas, such as deep pools that are thermally stratified or areas with cold groundwater upwellings characterized by a low DO concentration (Moyle, 2002).

Temperature

Temperature affects the metabolic rate (including growth) and the ability of rainbow trout to extract oxygen from water (Barnhart, 1986). Younger fish, such as those selected for the Lake Merced stocking program, are better able to survive higher temperatures than older fish (Molony, 2001). Rainbow trout in lakes select waters with temperatures between 7 °C (45 °F) and 18 °C (64 °F) and generally avoid temperatures greater than 18 °C, although higher growth rates may occur at higher temperatures if food is abundant as rainbow trout metabolic rate increases with temperature (Raleigh et al., 1984). Rainbow trout can tolerate warmer temperatures for short periods of time or if food is sufficiently abundant to meet the higher metabolic rates. In laboratory studies, growth has been shown to cease at 23 °C (7 °F) for fish fed full rations, and the upper incipient lethal temperature for rainbow trout is about 25 °C (77 °F) (EDAW, 2004). A daily average temperature of 20 °C or lower is typically used to describe suitable thermal conditions for rainbow trout in California. This temperature represents a level below which reasonable growth of rainbow trout may be expected. Therefore, rainbow trout thermal tolerance ranges may be characterized by average daily temperatures less than 20 °C (68 °F) and daily maximum temperatures (hourly) less than 24 °C.

Temperature data collected in Lake Merced from August 2011 to January 2013 indicate that minimum winter water temperatures are approximately 8.5 °C (47 °F) (measured in bottom waters) while peak summer temperatures may reach up to about 22 °C (72 °F) in waters near the surface (Figure 4-11). The seasonal average surface temperature in the summer (described in Section 4.4.1) is 19.4 °C (67 °F). Additionally, temperatures less than 20 °C generally persist within the mid- and lower-depth water column below 10- to 15-foot depths (Figure 4-11 and Appendix D). As discussed in Section 4.4, Conditions Affecting Lake Water Quality, Lake Merced is too shallow to develop more than weak intermittent temperature stratification. Under current conditions, the lake repeatedly stratifies during the period of approximately April through October, but these stratifications only last for an average of about 9 to 11 days before the water column mixes top to bottom and water temperatures are temporarily equalized. Maximum water temperatures during these periods of weak stratification typically range from about 18 °C (64 °F) in the hypolimnion to 22 °C (72 °F) in the epilmnion. During the remainder of the year, temperature conditions are relatively homogenous throughout the water column (median temperature about 16 °C as shown in Table 4-2). Thus, Lake Merced water temperatures are generally suitable for rainbow trout juvenile and adult rearing during most of the year throughout the water column, but summer maximum temperatures may at times create temporarily reduced growth conditions for the species in the epilimnion.

Dissolved Oxygen

The DO requirements of fish vary with species, age, prior acclimation, temperature, water velocity, activity level, and concentration of substances in the water. As temperature increases, the DO saturation level in the water decreases, while the DO requirement for the fish increases. As a result, an increase in temperature resulting in a decrease in DO can be detrimental to the fish. Rainbow trout are adapted to streams where DO is near saturation in surface waters and optimal summer rearing conditions are characterized as having DO concentrations of 7 mg/l or higher (Raleigh et al. 1984; Barnhart, 1986; Moyle, 2002). DO concentrations under 7 mg/l but above 5 mg/l are considered to be within the tolerance range for rearing rainbow trout (Molony, 2001) and concentrations under 5 mg/l are typically considered stressful with metabolic rate, swimming performance, and growth impaired, reducing overall survival (Barnhart, 1986; Bjornn and Reiser, 1991). The incipient lethal level of DO for adult and juvenile rainbow trout is about 3 mg/L or less, depending on environmental conditions, particularly temperature (Raleigh et al., 1984).

Continuous (hourly) DO monitoring data collected from August 2011 to January 2013 (Figure 4-12a) indicate that from November through March when cooler air temperatures prevail and the Lake is continually well mixed from top to bottom, DO levels in Lake Merced average above 7 mg/L and are considered suitable for rainbow trout. During periods of stratification (approximately April through October), however, DO levels in the hypolimnion periodically fall below 5 mg/L. During these periods, rainbow trout likely avoid the hypolimnion as much as possible, even though water temperatures are more suitable at the greater depths when the Lake is stratified. However, as described above, rainbow trout can utilize habitat with potentially stressful (<5 mg/l) DO levels for temporary periods as a refuge from high temperature areas. For example, Molony (2001) reports the distribution of adult rainbow trout to be restricted to areas where DO concentrations are above 2.5 mg/l. Additionally, fluctuating diurnal water temperatures during periods of stratification (Figure 4-14) likely aid in the overall habitat suitability, allowing rainbow trout to move between water depths with higher DO concentrations and lower temperatures over the course of the daily cycle.

pH

Precise pH tolerance and optimal ranges are not well documented for rainbow trout, but most trout populations can probably tolerate a pH range of 5.5 to 9.0 (Raleigh et al., 1984), while a range of 6.5 to 8.5 is considered to promote maximum productivity (RBI, 2004). Studies have shown that pH values of between 9.0 and 10.0 can result in partial mortality for rainbow trout (RBI, 2004). Based on continuous monitoring data collected from August 2011 to January 2013, Lake Merced is an alkaline lake with a pH range of approximately 7.5 to 9.3 (Figure 4-13a). The lake's surface pH level frequently peaks above 8.5 during sunny afternoons as a result of algal photosynthesis. Thus, periodically, Lake Merced surface water habitat is potentially stressful for rearing rainbow trout. As described for temperature, above, fluctuating diurnal pH levels (Figure 4-16) during periods of stratification likely improve the overall habitat suitability at varying depths, allowing rainbow trout to move between water depths with more suitable water quality over the course of the daily cycle. Additionally, research has shown that the species can acclimatize well to pH levels such as those in Lake Merced (Murray and Ziebell, 1984). Murray and Ziebell (1984) exposed rainbow trout to both gradual and rapid increases in pH, from an initial pH of about 8.0, to determine if they would acclimate to values above 9.0. Their results indicate that trout became acclimated to a pH of 9.8 when they were exposed to gradual increases over a period of 5 days, while trout exposed to an increase of pH to 9.5 in 6 hours experienced marked stress and 50 percent mortality. However, when the pH increase was to only 9.3 in 6 hours, the trout only exhibited a temporary loss of appetite (Murray and Ziebell, 1984).

Food Availability

Rainbow trout are opportunistic feeders. In streams, they feed on drift insects, benthic invertebrates (found in the bottom sediments), aquatic insects, snails, and small fish. Early in the season, lake resident fish feed on zooplankton, leeches, and benthic invertebrates, supplemented with terrestrial insects when other food is scarce. As they grow larger and reach lengths of about 30-35 cm (12-14 in), rainbow trout begin to feed on smaller fish. Lake Merced contains several appropriate food items for rainbow trout, including mysid shrimp, cladoceran zooplankton, and small fish of other species (Maristics, 2007). A 1977 CDFG fish diet study found that trout were feeding heavily on polychaete worms, mysid shrimp, and cladocerans (EDAW, 2004). Because polychaete worms are benthic invertebrates, their presence in the rainbow trout diet indicates that trout were feeding on the bottom of the lake.

Summary

Lake Merced does not provide suitable spawning habitat for rainbow trout, and the population is maintained through periodic stocking. Temperature, DO, and pH levels are generally suitable to rearing juvenile and adult rainbow trout throughout the water column from November through March when cooler air temperatures prevail and the lake is continually well mixed from top to bottom. During periodic stratification between April through October, varying depths (surface, mid, and bottom depths) are characterized as being generally within the water quality tolerance range for rearing rainbow trout, with diurnal fluctuations in combination with behavioral adaptations to summer rearing conditions likely contributing to overall habitat suitability. CDFW stocks about 2,000 pounds of trout per month in North Lake at an average size of about a half pound and 8 to 12 inches (Atkinson, 2012). A few additional fish plants occur throughout the year to coincide with community events and to reach CDFW's distribution goals (Atkinson, 2012). South Lake has a much smaller distribution allotment and is only stocked once or twice per year, usually in the spring, with similarly sized fish (Atkinson, 2012). Although no detailed water quality suitability studies are conducted in association with the stocking program, CDFW's routine pre-stocking suitability checks include water temperature and volume, as well as visual inspection of water condition, floating algal concentrations, aquatic plant growth, presence/absence of chemical sheen on lake surface, septic mud exposed on shore (smell), and dead or dying fish or wildlife (Atkinson, 2012). CDFW staff have not documented any need to cancel or relocate a load of fish for Lake Merced due to water quality issues in the past few years (Atkinson, 2012). Rainbow trout in Lake Merced are apparently quickly caught by anglers and cormorants (Maristics, 2007) and their populations likely fluctuate widely between stocking events.

Largemouth Bass

Largemouth bass are native to the eastern United States where they typically occur in lakes with extensive shallow areas and submerged vegetation. The maximum age of largemouth bass is 15 years. Growth and maturity are dependent on temperature and productivity, but in cooler waters maturity may occur in 3 to 5 years. In their native habitat, the normal growth rate of adult fish is typically around 1 pound per year (Stuber et al., 1982).

Optimal conditions in lakes include extensive areas (25 percent of surface area or more) that are less than 18 feet deep to support extensive emergent vegetation, and approximately 40 to 60 percent of surface area with depths greater than 18 feet to provide optimal overwintering habitat in northern latitudes (Stuber et al., 1982). South Lake is currently approximately 23 feet deep (see Section 4.2, Lake Merced Hydrology) and therefore provides suitable overwintering conditions for bass. However, due to the steepness of the banks, shallow areas supporting emergent vegetation are relatively sparse.

Adult bass are most abundant in areas with vegetation and other forms of cover such as tree trunks, brush, or large boulders. Conditions are optimal for adults when 40 to 60 percent of the littoral area has some form of cover, but levels of cover over 60 percent may reduce prey availability (Stuber et al., 1982). For fry, optimal conditions include 45 to 80 percent cover in the littoral area. Excessive cover also constitutes poor spawning and rearing habitat. In Lake Merced, cover in the littoral zone is limited. Where present, cover consists of thick stands of tules (*Scirpus* sp.) with nearly 100 percent coverage. Only the edge of the tule stands provides good cover conditions for adults, while some less dense areas may provide good cover for fry (EDAW, 2004). Estimates of useable cover in the littoral area of Lake Merced in 2004 ranged from about 5 percent for adults to about 10 percent for fry (EDAW, 2004).

Temperature

Optimal temperature for growth of adult and juvenile bass ranges from 24to 30 °C (75 to 86 °F) and very little growth occurs below 15 °C (59 °F) (Stuber et al., 1982). Optimal temperature for successful spawning and incubation is 20to 21 °C (68 to 70 °F) with a suitability range of 13 to 26 °C (55 to 79 °F) (Stuber et al., 1982). Optimal temperatures for fry growth are 27 to 30 °C (81 to 86 °F), with little growth occurring below 15 °C (59 °F) (Stuber et al., 1982). As described above, water temperatures in Lake Merced range from a minimum of approximately 8.5 °C (47 °F) during the winter to peak summer temperatures of up to about 22 °C (72 °F). Thus, Lake Merced provides conditions that, while not optimal, are within the tolerance range for largemouth bass during much of the year.

Dissolved Oxygen

Growth of largemouth bass is reduced at DO levels of less than 8 mg/L and a substantial reduction occurs below 4 mg/L (Stuber et al., 1982). Distress may be evident at 5 mg/L and levels below 1 mg/L are considered lethal (Stuber et al., 1982). As described above, DO levels in Lake Merced from November through March average well above 7 mg/L throughout the water column and are considered suitable for largemouth bass during those times. During periods of stratification, however, DO levels in the hypolimnion periodically fall below 5 mg/L. Largemouth bass likely avoid the hypolimnion as much as possible during stratification, and are expected to remain closer to the surface where both DO and temperature are more suitable for the species.

pH

Largemouth bass require a pH between 5.0 and 10.0 for successful reproduction, and optimal levels are in the range from 6.5 to 8.5 (Stuber et al., 1982). Based on continuous monitoring data collected from August 2011 to January 2013, pH levels in Lake Merced range from approximately 7.5 to 9.3 with frequent peaks in surface waters above 8.5 during sunny afternoons. Therefore, Lake Merced pH levels are generally suitable, but occasionally outside the optimal range, for largemouth bass.

Food Availability

Adult bass are solitary hunters and may establish temporary feeding territories. Adults and juveniles prefer shallow water near beds of aquatic plants where they hunt by day with a peak of activity at dusk. Soon after hatching, the larvae feed on rotifers and zooplankton. As they grow they change prey to aquatic insects and other fish, including their own species. Adults prefer other fish but will eat tadpoles, frogs, crayfish, and just about anything that fits in their mouth. An incidental effect of bass in small lakes bass can be a reduction in the abundance of native minnows (Moyle, 2002). This reduces minnow predation on zooplankton such as *Daphnia*, which in turn increases feeding by *Daphnia* on phytoplankton and may therefore result in lower phytoplankton abundance and increased water clarity (Maristics, 2007).

Common Carp

The common carp is a native species of Asia, but is currently found in all 48 contiguous states (Edwards and Twomey, 1982). Carp have little value as forage fish because their young stages are typically well hidden. They do have recreational value as sport and food fish, with some Lake Merced anglers specifically targeting carp (Maristics, 2007). Carp thrive in reservoirs, lakes, bayous, estuaries, farm ponds, and sewage lagoons (Edwards and Twomey, 1982). In lacustrine habitats, adults are usually found in association with abundant vegetation. Waters with a diversity of both shallow and deep areas represent optimal habitat (Edwards and Twomey, 1982).

Carp generally spawn in spring, but, in warmer, southern climates, spawning can occur from March to June, and, in cooler, northern climates, from May to June (Edwards and Twomey, 1982). Adults congregate and deposit their adhesive eggs on aquatic or submerged terrestrial vegetation or any other object the eggs can adhere to. Spawning over areas of dense vegetation would increase reproductive success. A self-sustaining population of carp spawns within the dense tule stands in Lake Merced in the spring (Maristics, 2004).

Temperature

High carp productivity is strongly correlated with warm, midsummer water temperatures, with a range of 20 to 28 °C (68 to 82 °F) being optimal for growth under laboratory conditions, while temperatures below 13 °C (55°F) and above 30 °C (86 °F) cause growth rates to decrease (Edwards and Twomey, 1982). The upper lethal temperature for adults is about 34 °C (93 °F) (Edwards and Twomey, 1982). As described above, water temperatures in Lake Merced range from a minimum of approximately 8.5 °C (47 °F) during the winter to peak summer temperatures of up to about 22 °C (72 °F). The temperature preference range of carp is somewhat lower than that of largemouth bass, but Lake Merced water temperatures are nevertheless at the lower end of that range, providing conditions for the species outside the optimal range during the winter.

Dissolved Oxygen

Adult common carp are very tolerant of low DO levels, a condition common in warm, eutrophic waters. Adults may feed in the oxygen-depleted hypolimnion (less than 2 mg/L DO) and can gulp surface air when DO is below 0.5 mg/L (Edwards and Twomey, 1982). The lower lethal oxygen level for juveniles is less than 1.0 mg/L (at temperatures below 20 °C), and growth rates are maximized at DO levels above 6 mg/L (Edwards and Twomey, 1982). DO levels in Lake Merced are generally adequate for carp, even during periods of stratification.

pH

Carp are common in reservoirs having a pH in the 8.5 to 8.7 range (Edwards and Twomey, 1982). A pH level of 10.5 or higher is lethal to the species, while a pH values less than 5.0 are reportedly harmful to the species (Edwards and Twomey, 1982). The elevated pH levels in Lake Merced are considered suitable for common carp.

Food Availability

Adult carp are opportunistic feeders which are able to utilize any available food source (Edwards and Twomey, 1982). Fry initially feed on zooplankton, but feed on phytoplankton when zooplankton density is low. As the young fish grow, they feed on littoral fauna and later on bottom fauna, taking in worms and larvae of aquatic insects as well as vegetable food, such as seeds, algae, and detritus (Edwards and Twomey, 1982).

Channel Catfish

Channel catfish are native to the Mississippi River basin and their greatest abundance is in the unleveed floodplains of the Mississippi and Missouri River drainages (McMahon et al., 1982.) They have been widely introduced in other areas in the United States and have established populations in most Pacific coast drainages.

Optimal lake habitat is characterized by large surface area, warm temperatures, high productivity, low to moderate turbidity, and abundant cover (McMahon et al., 1982). Survival and growth appear to be higher in large reservoirs (greater than 500 acres) than smaller reservoirs. Lake Merced, at approximately 300 acres surface area, would be considered a smaller lake. Littoral areas (less than 15 feet deep) composing at least 20 percent of the Lake surface, and with at least 40 percent suitable cover, are considered to provide adequate area for spawning, fry and juvenile rearing, and feeding habitat for channel catfish (McMahon et al., 1982). Spawning occurs in late spring and early summer when temperature reaches about 21 °C (70 °F), but is greatly inhibited if suitable nesting cover is unavailable (McMahon et al., 1982).

Temperature

Channel catfish prefer warmer temperatures. The optimal temperature range for growth is 26 to 29 °C (79 to 84 °F) for adults, 28 to 30 °C (82 to 86 °F) for juveniles, and 29 to 30 °C (84 to 86 °F) for fry (McMahon et al., 1982). Growth is poor at temperatures below 21 °C (70 °F) and ceases at temperatures below 18 °C (64 °F) (McMahon et al., 1982). As described above, water temperatures in Lake Merced range from a minimum of approximately 8.5 °C (47 °F) during the winter to peak summer temperatures of up to about 22 °C (72 °F). Therefore, Lake Merced provides suboptimal temperature conditions for channel catfish during most of the year.

Dissolved Oxygen

DO levels of 5 mg/L are adequate for growth and survival of channel catfish, but DO levels of at least 7 mg/L are optimal (McMahon et al., 1982). DO levels below 3 mg/L retard growth and feeding is reduced at levels below 5 mg/L (McMahon et al., 1982). As described above, DO levels in Lake Merced periodically fall below 5 mg/L in the hypolimnion during periods of weak stratification. Channel catfish may seek higher DO levels at shallower depths (where water temperatures are also more suitable for the species) during stratification, but the species is generally tolerant of even the lower DO levels periodically present in Lake Merced.

pH

The *pH tolerance* limits of *channel catfish* are not well defined, although the range for good growth of warmwater fish (6.5 to 9.0) probably applies to the species (McMahon et al., 1982). Lake Merced pH levels range from approximately 7.5 to 9.3 and thus generally fall within the presumed tolerance range of channel catfish.

Food Availability

Adult channel catfish are opportunistic feeders on terrestrial and aquatic insects, detritus and plants, crayfish, mollusks, and fish. Fish may form a large part of the diet of large catfish (greater than 20 inches in length) (McMahon et al., 1982). Feeding is primarily nocturnal and catfish use both vision and chemoreception to locate food.

4.6.2 Existing Habitat Conditions

As described above, Lake Merced supports a wide range of native and non-native fish species. In general, native species such as rainbow trout are considered coldwater fish while the non-native species such as largemouth bass are warmwater species. Similarly, many species require relatively high DO concentrations while others are capable of utilizing very low-DO environments. Thus, the fish assemblage in Lake Merced would not occur naturally anywhere in the world and is only present here due to decades of intensive management for recreational fishing. When comparing the habitat requirements and tolerance ranges of the present fishery to existing physical and water quality conditions within the Lake, it is evident that the Lake provides suitable conditions that are within the water quality tolerance range for many species, but does not provide optimal conditions for any of the primary recreational target species (Section 4.6.1, above). Existing water quality conditions are described in detail in Section 4.3, Lake Merced Water Quality, and form the basis for the following qualitative analysis of existing fishery habitat suitability within the context of the differing requirements of the primary recreational target species with regard to water temperature, DO, and pH.

Temperature

Temperature data collected from August 2011 to January 2013 indicate that from approximately mid-October through mid-April, the Lake is well mixed with a relatively uniform temperature profile throughout the water column. Water temperatures during that period range from about 9 °C to 18 °C. However, from late spring through early fall, rising air temperatures and solar radiation initiate stratification when the surface layers of the Lake are warmed by the sun. In June and July, surface water temperatures regularly exceed 20 °C while hypolimnion temperatures are often above 18 °C. Wind-driven mixing of the water column periodically disturbs this stratification. Data collected from August to November in 2011 show that complete mixing of the epilimnion and hypolimnion occurred on average every 9 to 11 days during the fall.

Water temperatures between October and April are well within the temperature preference range of coldwater species such as rainbow trout. The conditions during summer months are within the tolerance range for rainbow trout, especially with the diurnal variation described in Section 4.6.1 (however, growth rates at times of elevated temperatures would depend on food availability). Average water temperatures in Lake Merced are at the lower end of the preference range of warmwater species such as largemouth bass and channel catfish. Although these species are able to maintain self-sustaining populations under existing conditions, reproductive success and growth are likely limited by cool water temperatures in Lake Merced. Rainbow trout can tolerate such a temperature range.

Dissolved Oxygen

Continuous (hourly) DO monitoring data collected from August 2011 to January 2013 indicate that from November through March, when cooler air temperatures prevail and the lake is continually well mixed from top to bottom, DO levels average well above 7 mg/L. These levels are adequate for the range of cold and warmwater fish species present in Lake Merced, including rainbow trout. However, starting in April and continuing through October when stratification occurs, DO levels in the hypolimnion periodically fall below 5 mg/L. During this period, rainbow trout and largemouth bass likely avoid the hypolimnion. Channel catfish and common carp, on the other hand, may continue to utilize the hypolimnion during these periods due to their tolerance for lower DO levels, but growth and productivity of these species are likely periodically reduced at DO levels below 5 mg/l.

pH

Under baseline conditions, Lake Merced has an elevated pH range, particularly in surface waters where sunlight fuels algal growth. The pH level frequently peaks above 8.5 during sunny afternoons as a result of algal photosynthesis; however, the actual pH value reached is significantly influenced by the background pH level, which is dependent upon the alkalinity or abundance of alkaline minerals in the water. As described above, a pH range of 6.5 to 8.5 is considered optimal for most freshwater fish species, and levels above 9.0 are considered stressful. However, the majority of elevated pH (i.e. greater than 8.5) levels occur in the upper layer of the water column, and fish are able to move into more favorable pH levels in the mid- to lower depths, depending on DO and temperature conditions and species-specific tolerance ranges. More importantly, fish are able to acclimate to many environmental variables, including pH, that may be considered at the upper or lower tolerance range limits.

A review of the hourly pH data collected at Lake Merced from August 2011 to January 2013 indicates (a) that pH increases to levels above 9.0 are infrequent and gradual, and (b) that pH levels do not generally increase above the 9.3 level to which rainbow trout can acclimate fairly rapidly. Although similar analyses are not available for the other three primary angler-target species in the Lake (largemouth bass, common carp, channel catfish), these species are generally more tolerant of water quality perturbations than rainbow trout, and it appears reasonable to assume that these species can similarly acclimate to occasional gradual pH increases in Lake Merced, as evidenced by their ability to maintain self-sustaining populations in the Lake.

CHAPTER 5
Vista Grande Canal Existing Conditions

5.1 Vista Grande Canal Hydrology

5.1.1 Vista Grande Watershed

The existing Vista Grande stormwater drainage system comprises stormwater sewers, box culverts, manholes, catch basins, and flow equalizations facilities, with approximately 30 miles of pipe, ranging in size from 6 to 72 inches diameter, plus some box culverts, all of which currently are maintained by the Street Division of the Daly City Public Works Department (RMC, 2006). This system collects storm and authorized non-storm flow (flow) from a 2.5-square-mile area in Daly City and unincorporated San Mateo County (Basin) and conveys those flows via several underground culverts to the Canal. The Basin is bordered by San Francisco to the north, the Colma Creek watershed to the south and east, and Thornton State Beach and the Pacific Ocean on the west. The Basin drains to the Pacific Ocean via the Canal and Tunnel (described in Section 5.1.2, below). The urban portion of the Basin (i.e., not including those portions within golf courses) is divided into three sub-basins (**Figure 5-1**), each of which contribute flow to the Canal headworks (**Figure 5-2**) at the intersection of John Muir Drive and Lake Merced Boulevard. The sub-basins that contribute flow to the Canal are summarized as follows:

- Sub-Basin #1 has a 118-acre drainage area and flow is conveyed to the Canal headworks via a 24-inch culvert.
- Sub-Basin #2 has a 397-acre drainage area and flow is conveyed to the Canal headworks via a 60-inch culvert.
- Sub-Basin #3 is the largest of the sub-basins with a 1,175-acre drainage area and flow is conveyed to the Canal headworks via a 7-foot by 6-foot box culvert.

Like the larger Lake Merced Watershed, the Basin has also experienced substantial urban development. The Basin is a densely developed urban community surrounded by hills on the east, west, and south (RMC, 2006). The primary land uses are residential, commercial, and recreational with a high percentage of impervious surfaces, such as roads, roofs, and parking lots. The watershed contains portions of two large golf courses and completely encompasses a third. The major hydrologic features associated with the watershed area include the Vista Grande stormwater drain system, the Canal and Tunnel, and Lake Merced. Residential land uses cover nearly half (45 percent) of the land area within the watershed, and right-of-way areas consisting primarily of streets and sidewalks make up approximately 27 percent. An additional 7 percent of the watershed consists of institutional land uses (schools and other facilities) and 6 percent consists of commercial uses. Just 0.3 percent of the watershed is covered by industrial uses (Sanchez, 2012). The California Office of Environmental Health Hazard Assessment (OEHHA) estimates that rainfall on these land

SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-1
Vista Grande Drainage Basin and Sub-Basins

SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-2
Vista Grande Canal Headworks

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use types typically runs off at rates as high as 70 to 90 percent (OEHHA, 2010). In addition to these land uses, the basin includes approximately 9 percent recreational land, 4 percent vacant land, 0.4 percent agriculture, and 2 percent other land uses (Sanchez, 2012). These land uses typically result in lower rates of runoff than the developed uses described above; however, they do include some impervious surfaces.

5.1.2 Vista Grande Canal and Tunnel

The Canal collects storm and authorized non-storm flows from the Basin and discharges them to the Tunnel. The existing Canal lies parallel to the southwest shores of Lake Merced and adjacent to John Muir Drive in San Francisco. The Canal is a 3,600-foot-long brick-lined trapezoidal channel structure. As the Canal tapers downstream, its dimensions vary. It is 11 feet deep by 11 feet wide with a flow capacity of 900 cubic feet per second (cfs) in some places and 7 feet deep by 4 feet wide with a flow capacity of 500 cfs in other places (RMC, 2006). There is additional capacity provided as a result of earth banks that have built up over the top of the engineered Canal as well as containment berms (John Muir Drive bank) and natural steep slopes (Olympic Club bank) adjacent to the Canal.

At the terminus of the Canal is the mouth of the Tunnel, the primary outlet for stormwater from the Basin, constructed in 1897. The Tunnel is a 3,000-foot-long, 7-foot-tall by 4-foot-wide, egg-shaped gravity conduit with an average cross-sectional area of 22.25 ft^2 (RMC, 2006). Flows exiting the tunnel discharge to the beach below Fort Funston through an ocean outlet structure. The Tunnel has a non-surcharged capacity of 170 cfs, which is not adequate to convey peak Canal storm flows, periodically resulting in flooding in low-lying residential areas and along John Muir Drive. Wet weather flows in excess of the capacity of the Canal and the Tunnel have resulted in local flooding and overflows across John Muir Drive into Lake Merced, causing property damage, bank erosion, traffic nuisances, and public safety issues (RMC, 2006).

5.2 Vista Grande Water Quality

5.2.1 Conditions Affecting Stormwater Quality

Daly City is the largest city in San Mateo County. The Vista Grande Basin within Daly City has been highly urbanized for many years and contains the various urban land uses as described in Section 5.5.1. The type and concentration of substances in urban stormwater can vary considerably, both during the course of a storm event and from event to event at any given area (based on the intensity of rainfall), as well as from site to site within a given urban area (based on land use characteristics) (USEPA, 1993).

Stormwater runoff and authorized non-stormwater flows (conditionally exempt discharges) from Daly City and the other San Mateo County Cities have been regulated under Municipal Separate Stormwater System (MS4) NPDES permits since 1999. These MS4 permits, including the current MRP, have contained increasingly prescriptive requirements, typically in the form of BMPs, for the cities to implement actions to minimize the extent of pollutants in stormwater to the Maximum Extent Practicable (MEP). Daly City has an effective stormwater management program that fully implements the requirements of the MRP. For example, street sweeping is conducted weekly, removing potential pollutant particulates from land based sources, vehicular based sources, atmospheric deposition, and other sources that would otherwise accumulate during dry weather periods and be conveyed later into stormwater drains and waterbodies.

5.2.2 Previous Vista Grande Canal Water Quality Monitoring

For this WQA, existing data from and reports on the Canal were reviewed to determine baseline hydrologic and water quality conditions for the Canal during base flow and storm events. These data sources included technical memoranda prepared for a previous SFPUC proposal for a constructed treatment wetland along John Muir Drive (RMC, 2007), an initiative to raise Lake Merced water levels (EDAW, 2004), and the feasibility of diversions of Canal water to Lake Merced (CH2MHill and Duffey, 2001) as well as previously unpublished SFPUC data. The hydrologic and water quality data for the Canal are limited and sporadic in nature, with sampling results presented for various locations, differing constituents and physical parameters, and generally only limited time periods (short focused studies with differing goals and objectives). The previous Daly City collected data are reported to be from the Canal just west of Lake Merced Boulevard (CH2MHill and Duffey, 2001). The SFPUC data were collected in the Canal just south of Lake Merced at the mouth of the tunnel. Water quality data were also collected from a stormwater drain in the Daly City WWTP parking lot and from a stormwater drain collecting surface runoff from the Olympic Club. Also, water quality data presented for the Canal are not linked to flow in the majority of available studies, making it problematic to determine if reported values correspond to base flow or storm flow. While these monitoring data demonstrate ranges for temperature, DO, and pH typical for urban runoff, they are of limited use for establishing baseline Canal water quality conditions for the reasons presented above.

5.2.3 Vista Grande Canal 2011-2012 Monitoring

As discussed above, very limited and disparate historic data exist regarding Canal base flow and storm flow water quality (see Section 5.2.1). Therefore, Dry Season and Wet Season Water Quality Monitoring Plans were developed, with input from SFPUC and RWQCB staff for both the Canal and South Lake (**Appendix B**) to support the assessment of potential water quality effects to Lake Merced from diversions of water from the Canal. This section includes an overview of the water quality and hydrologic sampling rationale and methodology employed by the monitoring program. Also summarized and presented in detail in Appendix B are the results of the 2011-2012 monitoring program. The data collected from the Canal during the 2011-2012 monitoring period provide the most comprehensive available assessment of the quality of stormwater that could be diverted to Lake Merced.

Methods

The primary goal of the monitoring program was to provide hydrologic and water quality data to characterize baseline conditions in the Canal, including storm event flows and seasonally variable base flow conditions (typically base flow is lower during winter months than summer months due to reduced irrigation return flow). Water quality and hydrologic data collection was conducted in 2011 and 2012 to characterize water quality and quantify flows during seasonal dry and wet periods. Additionally, the monitoring program was designed to provide data to support development of the conceptual design of the proposed constructed treatment wetland based on the winter and summer base flow and stormwater quality in the Canal.

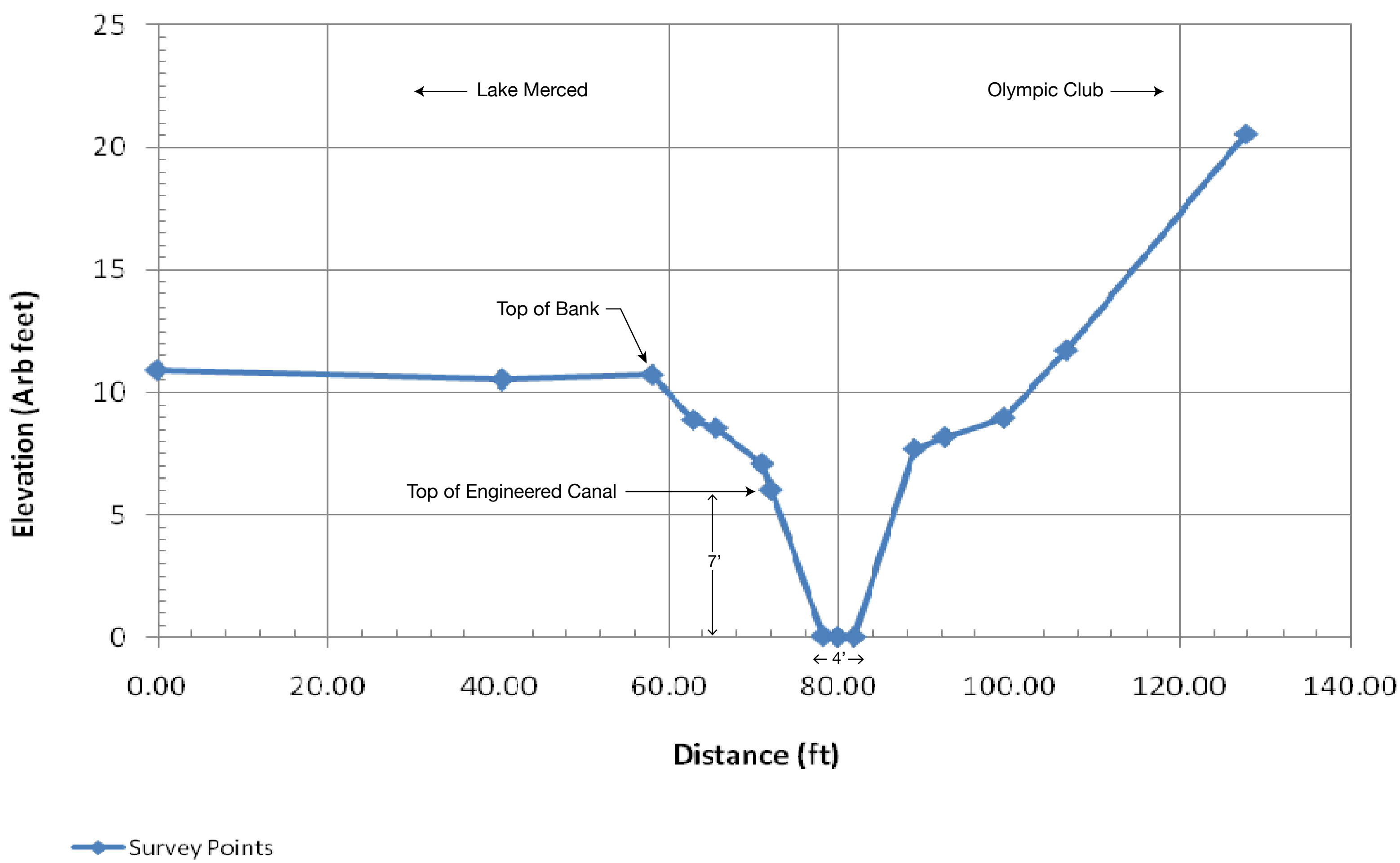
Dry season monitoring was conducted between approximately August 15 and October 31, 2011 and wet season monitoring between approximately November 20, 2011 and May 31, 2012. Monitoring was conducted in the Canal and Lake during the same time period using a consistent methodology and assessing a consistent set of water quality parameters to develop a comparable data set for comparison to potential project conditions, as discussed in Chapter 6.

Flow and water quality monitoring in the Canal took place at station VGC-1 (see Figure 4-5), which is located in the Canal, adjacent to the parking lot at the south end of South Lake. Based on field reconnaissance, VGC-1 was selected to avoid areas of backwatering or velocity changes that may occur at some constricted points along the Canal. Station VGC-1 is a straight section of canal that is 7 feet deep by 4 feet wide (**Figure 5-3**) with a flow capacity of 500 cfs. It has developed earth banks that have built up over the top of the engineered canal as well as containment berms (John Muir Drive bank) and natural steep slopes (Olympic Club bank). Flow (base flow and storm flow) was monitored through use of an ISCO Area-Velocity continuously recording data logger (**Figure 5-4**). During the dry season, temperature, DO, and pH were measured using a hand-held water quality meter and grab samples were collected for laboratory analysis of specific constituents two times per month at station VGC-1. Dry season sampling events occurred on August 17, September 1, September 15, September 30, October 13, and October 27, 2011.

During the wet season, temperature, DO and pH were measured using a hand-held water quality meter during base flow conditions. During storm events where Canal flow was equal or greater than 5 cfs,[9] a multi-probe water quality sonde with logging capability was used to continuously record temperature, DO, and pH at 15-minute intervals (Figure 5-4). During precipitation events, samples were collected using an ISCO automatic water sampler. Flow-interval (volumetric paced) sampling was used to enable calculation of the Event Mean Concentration (EMC, described in detail below). After completion of each sampling, field staff created a composite event sample and samples were delivered to a commercial laboratory for analysis of the specific constituents listed in Table 1 of the 2011-2012 Wet Season Water Quality Monitoring Plan (Appendix B). Wet season storm sampling events took place on January 19, January 23, February 28, March 13, March 14, and March 16, 2012. In addition, four base flow samples were collected during the wet season to characterize the quality of water that would be diverted to Lake Merced through the proposed constructed treatment wetland discussed in Chapter 2, Project Description Overview. Wet season base flow sampling occurred on October 4, 2011[10] and January 13, January 24, February 6, and February 17, 2012.

[9] Flows less than 5 cfs were not of sufficient depth to submerse the sonde multiprobe array for water quality monitoring.

[10] Note that although the October 4, 2011 base flow sampling event took place during the dry season window (August 15 to October 31), it was included as a wet season sampling event because it occurred after the first rain event of the season on October 3, 2011.



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-3
Vista Grande Canal Cross-Section

SOURCE: ESA

Figure 5-4
Vista Grande Canal Stormwater Quality and Flow Monitoring Station

The following discussion provides details regarding the monitoring instrumentation installation and the methodology for the water quality and hydrologic sampling and analysis during storm events.

Storm Event Sampling

The timing and magnitude of storm events is hard to predict, and the impervious surfaces that characterize the Vista Grande watershed results in runoff events that produce brief and rapid peak flows. Therefore, to accurately establish the concentrations of constituents contained in storm flow, it is necessary to sample at multiple times during a runoff event. It can be difficult for staff to respond quickly enough to successfully capture stormwater samples in a representative manner for water quality characterization. For these reasons, automated sampling equipment was used to sample flow from the Basin.

Automated sampling represents a more reliable methodology (less potential error) than manual sample collection. Generally, commercially available automated samplers contain similar components, such as programmable operation, water level recorder, sample collection pump, and sample bottles. Equipment was required for this study to monitor flow at the sample point and to determine the sample frequency for flow-weighted samples in order to determine the EMC[11] of various constituents for storm events (flow-weighted mean concentration). To collect flow-weighted samples, an ISCO 6100 series autosampler was used in conjunction with an ISCO 2100 series Area-Velocity flow meter and flow module. Canal flow was monitored and recorded into the system memory in 15-minute intervals during base flow periods. When specified minimum flow thresholds (discussed below) were exceeded, the Canal flow was monitored continuously to automatically calculate the flow-weighted sample interval during each storm event.

While few guidelines are available for developing automated stormwater sampling methodologies, a number of key standardized sampling strategy components have been assessed in peer reviewed literature that minimize potential sampling error (Harmel et al., 2003). Common sampling strategy components described in the literature and applicable for automated sampling of Canal storm flow include: setting low minimum flow thresholds, using flow-interval sampling, and using composite sampling to limit the number of samples required for accurate stormwater quality characterization. Consideration and incorporation of these components is needed to achieve a balance between accurate characterization of stormwater quality (and pollutant loads) and various limitations (such as budget, equipment, and site-specific considerations).

Sampling Strategy

The sampling strategy components typical to automated sampler operation, such as setting a minimum flow threshold, determining sample interval, and selecting discrete or composite samples, affect the timing, frequency, and number of samples collected (Harmel et al., 2003). All of these variables can affect data quality as well as sampling and analysis costs. It is therefore critical that sample component interactions be considered as part of developing a methodology that would satisfy overall project goals. The methodology employed for stormwater quality

[11] Event Mean Concentration represents an arithmetic mean of individual sample concentrations collected on equal discharge intervals.

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characterization for the 2011-2012 monitoring program was appropriate for characterization of a small watershed (relatively homogenous watershed with a limited number of sub-watershed contributions). Additionally, hydrologic assessment of the project site and associated watershed determined that water quality could be adequately sampled at a single intake point in the Canal because storm flow is likely well mixed along the extent of the homogenous Canal structure.

To meet monitoring goals, the wet season monitoring plan specified a maximum of six storm events be sampled to determine representative water quality characterization of wet season storm flows. Additionally, analysis of each storm event was based on composite sample representativeness to determine whether sampling met minimum acceptable storm capture parameters (number of aliquots collected and percent storm capture). Samples that did not meet these criteria were not sent to the laboratory for analysis. Percent storm capture is the percentage of the total event flow that passes the sampling station during which sample collection occurred (i.e. the portion of the runoff represented by the composite sample) (Caltrans, 2003). Percent storm capture is calculated by dividing the flow volume that passed the sampling station during sample collection by the total flow that passed the sample station during a discrete storm event. The minimum acceptable number of sample aliquots and the minimum acceptable percent storm capture for representative storm flow sampling can be based on the total event precipitation (Caltrans, 2003). **Table 5-1** provides guidelines for selecting the number of sample aliquots required for a forecast storm event to ensure adequate representativeness of a flow-weighted composite sample. Generally a higher number of aliquots develops a more representative composite sample.

TABLE 5-1
STORM MONITORING EVENT REPRESENTATIVENESS REQUIREMENTS

Total Event Precipitation (in)	Minimum No. of Aliquots	Percent Capture Requirement
0-0.25	6	85
0.25-0.5	8	80
0.5-1	10	80
>1	12	75

SOURCE: Caltrans, 2003

Minimum Flow Threshold

Development of an automated stormwater sampling methodology requires selection of a minimum flow depth threshold at which automated sampling is initiated and terminated. When flow and depth exceed the minimum threshold levels, sampling initiates and continues until the flow recedes below this level. The minimum flow threshold and event duration directly affect the number of samples collected during a storm event. A high minimum flow depth threshold reduces the number of samples collected and can increase the difference between the measured and true pollutant load. A low minimum flow depth threshold increases the number of samples collected, but may result in sampler capacity being exceeded. Harmel et al. (2003) found that substantial error is introduced as minimum flow depth thresholds are increased. For the 2011-2012 monitoring program, the minimum flow threshold was set as close to wet season base flow as possible, but was limited by the minimum sampler operating depth of 6 inches. The minimum flow threshold for the 2011-2012 wet season monitoring was set at 5 cfs following experimentation with lower minimum flow thresholds. Minimum flow thresholds below 5 cfs caused periodic pump malfunction. To avoid exceeding the sampler capacity, a flow-interval pacing model was developed to maximize the number of samples collected during a storm event up to the maximum number of potential autosampler aliquots.

Flow Interval Sampling

Once the flow exceeds the minimum flow threshold, a sample interval must be selected for capturing a representative proportion of the storm hydrograph. Sample intervals may be time-based (such as every 5 minutes) or volume-based (such as every 50,000 cubic feet). Typically, samples are collected on a constant time- or volume-based interval. Based on review by Harmel et al. (2003), flow-interval sampling generally represents storm loads to a higher degree of accuracy because flow-interval sampling results in a greater proportion of samples being collected at higher flow rates. Additionally, individual flow-interval samples can be composited to produce a flow-weighted EMC. For the greatest degree of accuracy, small flow interval samples are needed to increase the number of samples collected. Statistical sampling theory indicates that a higher number of samples results in a better estimate of population characteristics.

To sample the entire suite of constituents identified in the monitoring plan for storm event water quality characterization, a minimum event composite sample volume of approximately 17 liters was required. Therefore, flow-paced sample collection was designed, on an event-by-event basis, to maximize the number of sample aliquots collected to ensure that a sufficient volume of samples was available to analyze the full suite of selected water quality constituents. To set appropriate flow pacing for sample collection specific to a given storm event and to maximize the number of samples collected without exceeding autosampler capacity, Brown and Caldwell (2011) developed an Excel-based model for calculation of flow-weighted sample collection. This sampler pacing model allowed autosampling of any given storm event during the 2011-2012 wet season to be based on an appropriate flow-interval that captured a representative portion of the hydrograph above the minimum depth flow threshold and also maximized the number of samples (total sample volume) without exceeding the autosampler capacity.

In order to set appropriate flow-based sample intervals for a given storm event, weather was tracked using the National Oceanic and Atmospheric Administration (NOAA) National Weather Service website. When precipitation was predicted for the watershed, the storm duration and the predicted Quantitative Precipitation Forecasts (QPF) for Daly City were utilized in the sampler pacing model to calculate an appropriate flow-based sampler pacing value approximately 24 hours prior to the predicted precipitation start time. This flow-based pacing value was then entered into the autosampler setup program remotely via a telemetry link.

Composite Sample Collection

Storm sampling can be collected and assessed through use of discrete (one sample per bottle) or composite (collection of more than one sample per bottle) samples. Discrete sampling allows for characterization of pollutant distribution within a single storm event. However, composite sampling allows for longer duration and larger magnitude events to be sampled. Also, when based on flow-interval sampling, composite samples can be used to reliably determine EMC (the concentration from the composite sample is the EMC) and the EMC can be multiplied by the corresponding runoff volume to approximate the storm load of a given constituent (Harmel et al. 2003).

The autosampler sequentially collects 500 ml sample aliquots into 24 1 L sample bottles, filling one bottle (2 aliquots per bottle) before starting the next. A composite storm sample methodology was used to determine the EMC for each sampled storm event, and to ensure that long-duration (multiple day) or large (more than 1 inch) storm events could be adequately sampled. To determine how to composite the collected aliquots towards accurate calculation of an EMC, the storm event hydrograph and sample collection times were reviewed in the field via download of flow data from the ISCO Area-Velocity meter and autosampler to a laptop. This allowed sample aliquots to be accurately grouped and composited for a discrete storm event. At the completion of sampling for each storm event, ESA field staff created a composite event sample by consolidating all or a portion of the sampled aliquots into one large container. This large container was then used to fill constituent sample bottles. Water quality samples were collected from the autosampler for delivery to a commercial lab for analysis within 24 hours of a precipitation event.

Storm Event Sampling Results

Wet season water quality monitoring was conducted for the 2011-2012 wet season from November 1, 2011 through to May 31, 2012. During this time, water quality was characterized simultaneously in Lake Merced and the Canal for a total of six discrete storm events (**Table 5-2** and Appendix B). In addition to complete characterization of the six storm events, the first storm event of the wet season, occurring on October 3, 2011, was sampled by hand for general characterization of water quality.

Hydrologic monitoring during the 2011-2012 wet season revealed that, in general, storm events within the Basin tend to result in flashy runoff patterns in the Canal. Flow monitoring over the sampling season recorded that runoff events generally lasted 3 to 17 hours (with an average of 9 hours), and that peak runoff was reached after approximately 2.5 hours, on average. As a result, the contribution of runoff from the Canal to Lake Merced would be expected to be very flashy.

Storm event sampling summaries are provided below and water quality results for these events are presented in Appendix B.

- **First Storm Event:** The first storm event of the 2011-2012 monitoring period that resulted in flows exceeding 5 cfs in the Canal occurred on October 3, 2011 (during the dry season monitoring period). This storm event generated a peak flow of approximately 30 cfs with flows exceeding base flow levels for a duration of approximately 8 hours. Because the storm event occurred early in the season before wet season monitoring instrumentation was set up, periodic grab samples were collected manually for analysis. Two grab samples were obtained from the Canal in total. The first grab sample was collected during the rising limb of the event hydrograph and was analyzed for the full suite of water quality constituents described for the Lake (see Table 4-2 and Appendix B). A subsequent water quality sample was collected on October 4, 2011, during base flow conditions following the storm event.

TABLE 5-2
STORM MONITORING SUMMARY

	Storm Event Date (2012)					
	1/19	**1/22**	**2/29**	**3/13**	**3/14**	**3/16**
Total Event Precipitation (in)	0.11	0.55	0.36	0.38	1.02	1.09
Antecedent Dry Period (Days)	19	<1	13	11	<1	<1
Peak Flow (cfs)	18	257	184	33	115	193
No. of Aliquots Collected	48	48	36	24	71	48
Storm Event Volume (acre-feet)	3.2	37.9	17.3	21.6	79.7	42.7
Storm Event Capture Volume (acre-feet)	2.8	16.0	16.7	18.8	54.4	38.8
Percent of Hydrograph Sampled[a]	87	42[b]	96	87	68	91
Storm Volume as % of LM Storage[c]	0.06	0.67	0.31	0.38	1.42	0.76

NOTES:

[a] Based on calculation of the volume of the event hydrograph sampled as a percentage of the entire event hydrograph volume above base flow conditions. However, base flow somewhat arbitrarily determined for each storm event due to base flow conditions being under continuous fluctuation. Additionally, not all storms resulted in a return to pre-storm base flow levels following a sample even. In these cases, percent capture derived from base flow during pre-storm condition to the point of lowest flow following sample completion before the subsequent storm event and rising limb of next event hydrograph.

[b] Although total event capture did not meet requirements for storm event monitoring representativeness (percent capture), sample collection successfully captured representative flow-paced samples from base flow to peak flow (and partially beyond) on the event hydrograph. The EMC calculated for this event is therefore likely higher (more conservative) than the actual EMC, but is conservatively representative for purposes of characterizing the seasonal mean for various pollutant loads.

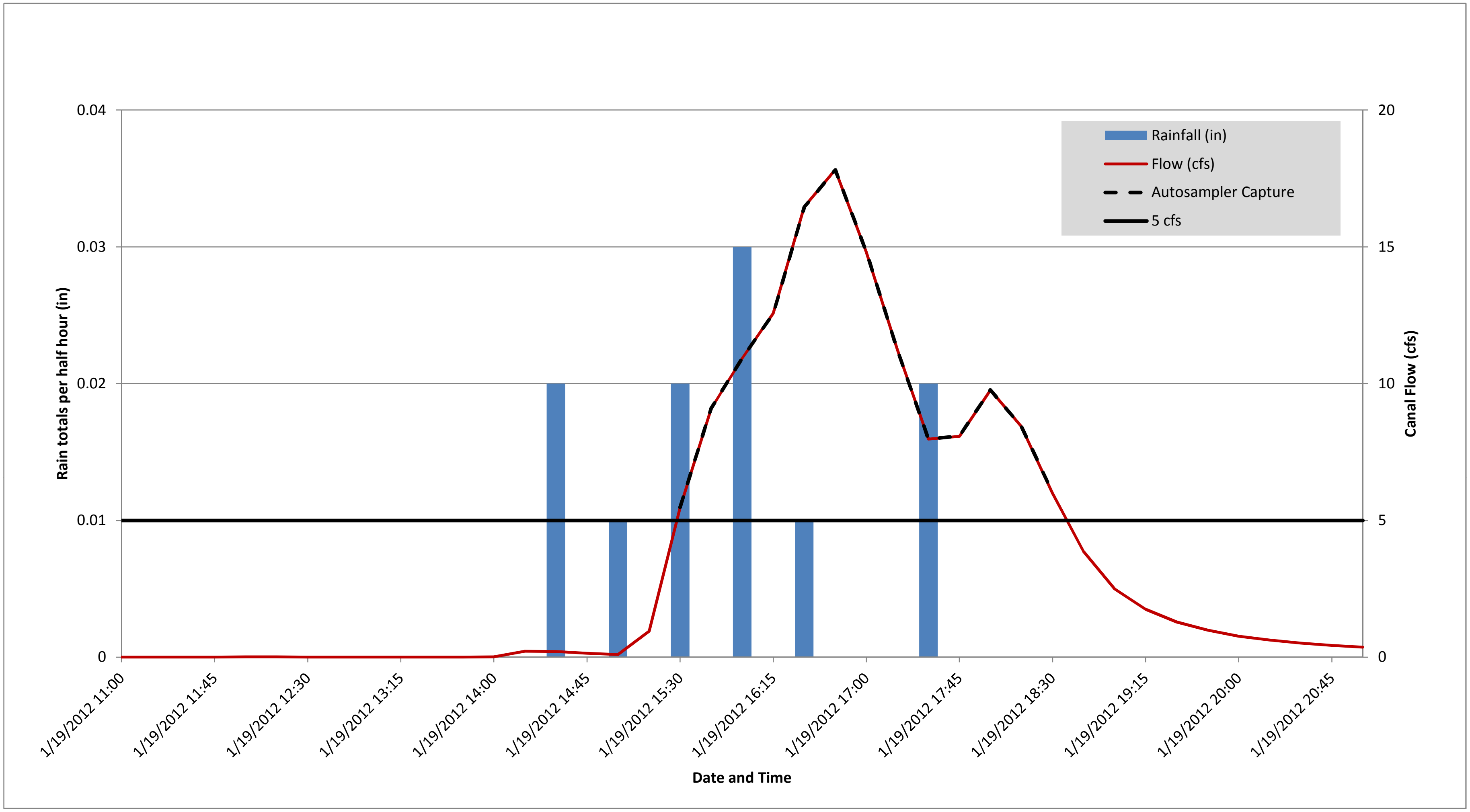
[c] Based on Lake volume of 5,625 acre-feet (as described in Chapter 4).

The following summarizes individual wet season storm event conditions:

- **January 19, 2012:** This storm event generated a peak flow of 18 cfs with storm flow exceeding base flow over a 9-hour period. The storm event was preceded by a dry interval of 19 days since the previous storm event. Forty-eight flow-paced aliquots were collected representing an event capture of 87 percent of the event hydrograph (**Figure 5-5**).

- **January 22, 2012:** This storm event generated a peak flow of 257 cfs with storm flow exceeding base flow over an 1- hour period. The storm event was preceded by a dry interval of less than 1 day since the previous storm event. During this storm event, 48 flow-paced aliquots were collected but the total precipitation volume and rainfall rate exceeded predictions for the storm and the autosampler had insufficient capacity to capture the entire storm hydrograph based on the flow-pacing utilized for the event. However, the collected aliquots successfully captured the entire rising limb of the event hydrograph up to peak flow and a proportion beyond the peak flow on the falling limb of the hydrograph (**Figure 5-6**). Therefore, although only 42 percent of the total event hydrograph was sampled by volume, the results of water quality analysis were still utilized to estimate a conservative EMC by assuming the characteristic of the rising limb were similar to those for the falling limb of the event hydrograph in terms of water quality (see Table 5-2).

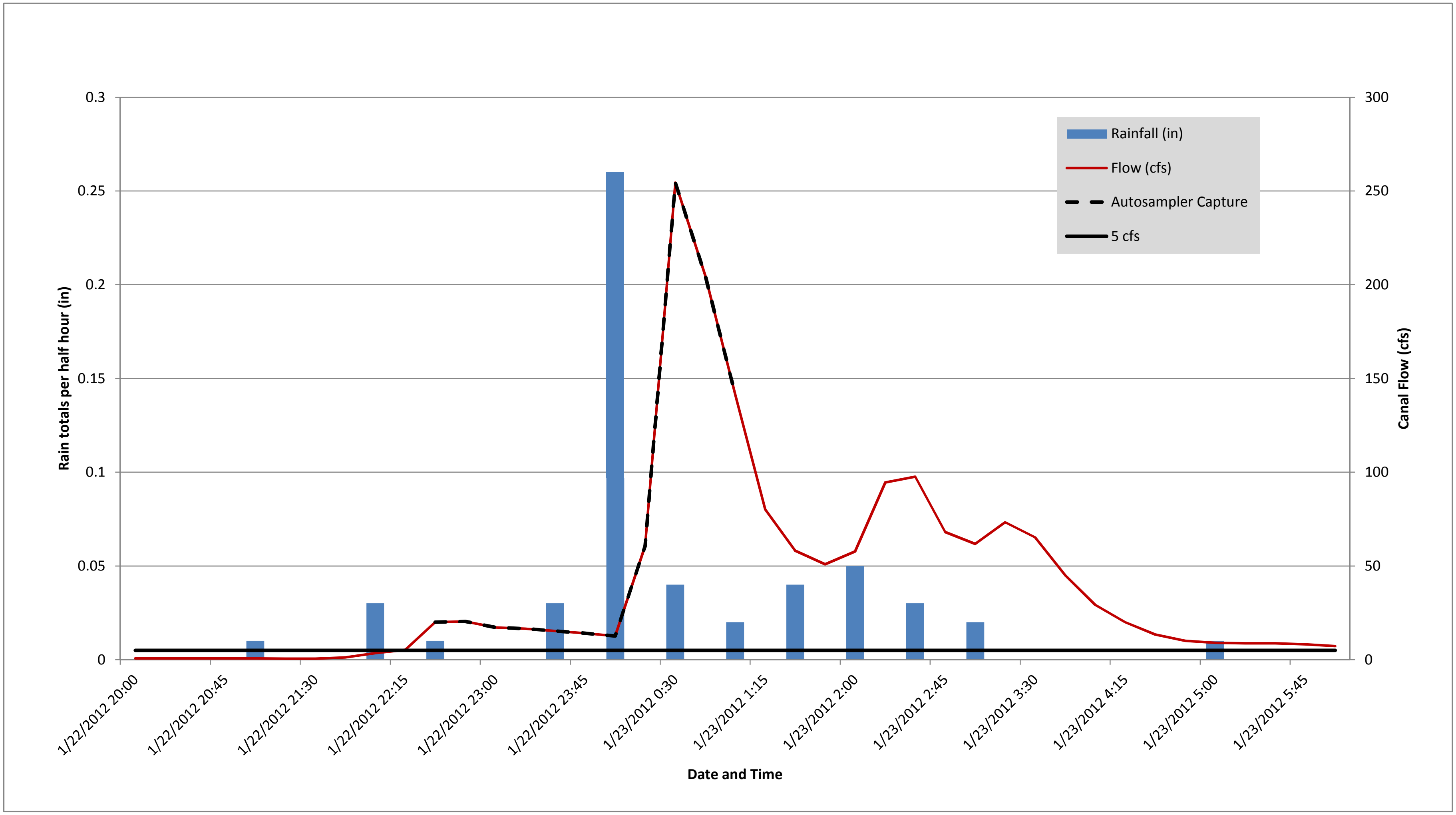
- **February 29, 2012:** This storm event generated a peak flow of 184 cfs with storm flow exceeding base flow over a 15-hour period. It was preceded by a dry interval of 13 days since the previous storm event. During this event, 36 flow-paced aliquots were collected representing an event capture of 96 percent of the event hydrograph (**Figure 5-7**).



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-5
January 19, 2012 Storm Hydrograph

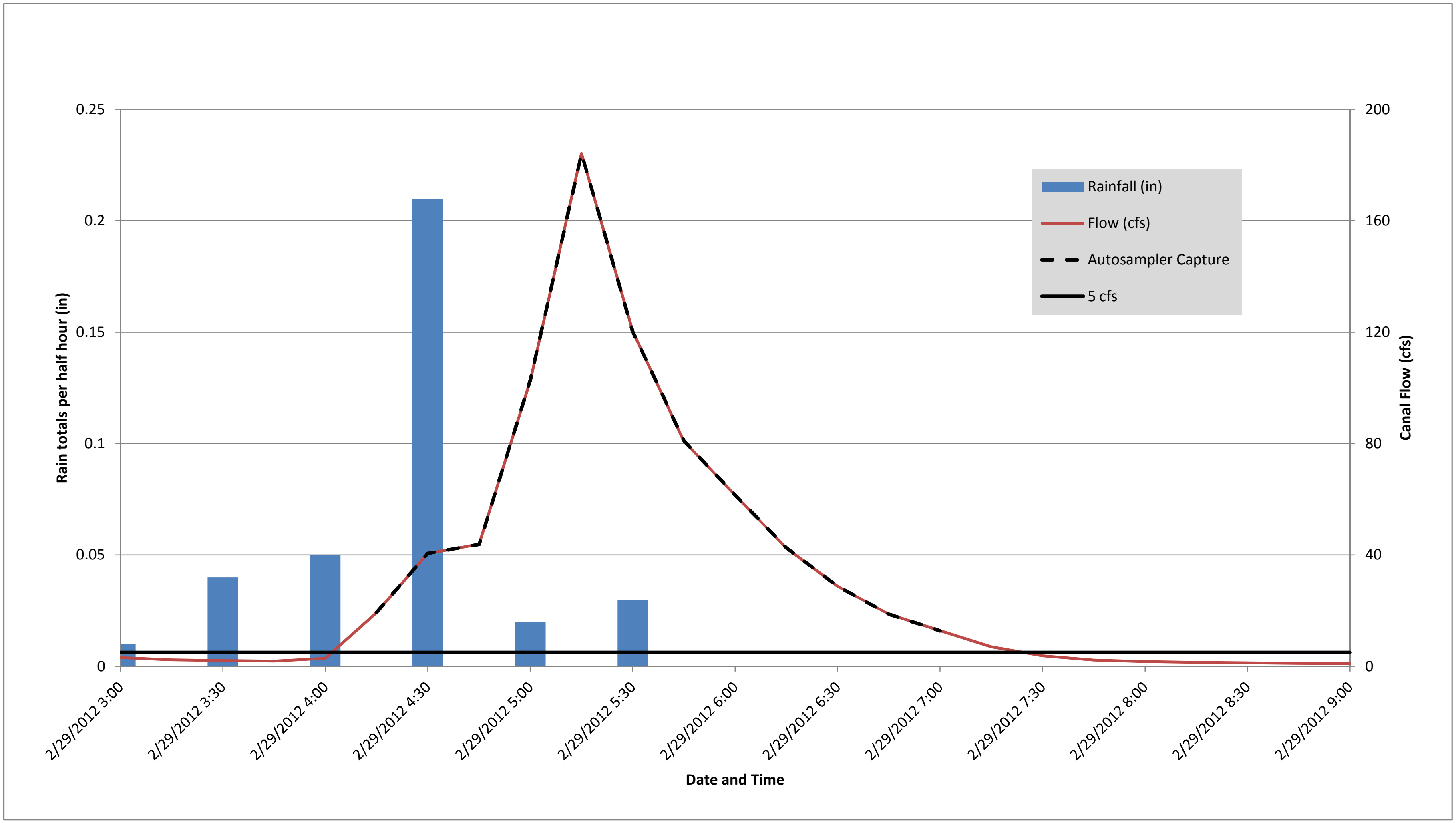


SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-6

January 22, 2012 Storm Hydrograph



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-7
February 29, 2012 Storm Hydrograph

- **March 13, 2012:** This storm event generated a peak flow of 33 cfs with storm flow exceeding base flow over a 15-hour period. It was preceded by a dry interval of 11 days since the previous storm event. During this event, 24 flow-paced aliquots were collected representing an event capture of 87 percent of the event hydrograph (**Figure 5-8**).

- **March 14, 2012:** This storm event generated a peak flow of 115 cfs with storm flow exceeding base flow over a 22-hour period. It was preceded by a dry interval of less than 1 day since the previous storm event. During this event, 71[12] flow-paced aliquots were collected representing an event capture of 69 percent of the event hydrograph (**Figure 5-9**).

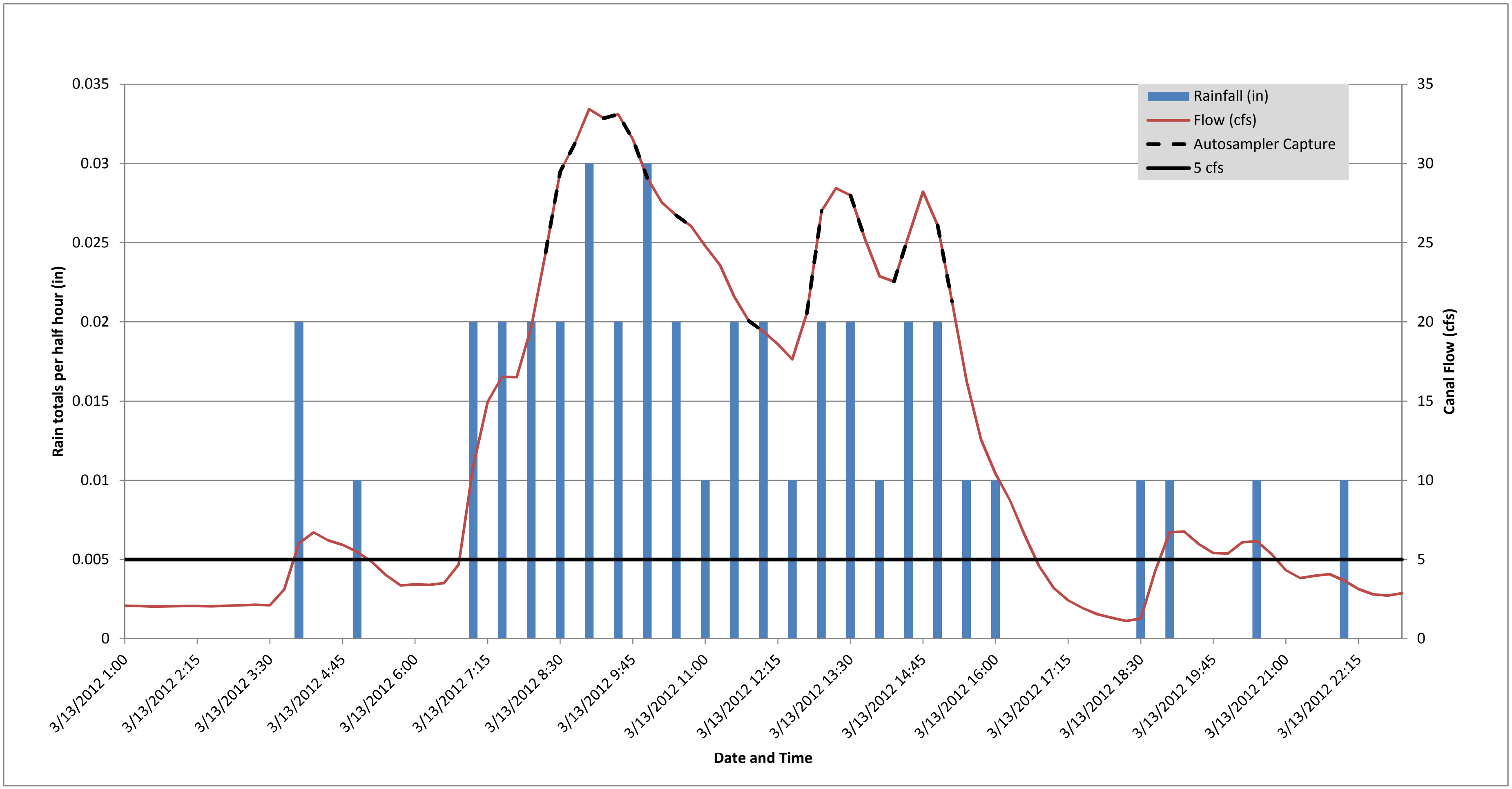
- **March 16, 2012:** This storm event generated a peak flow of 193 cfs with storm flow exceeding base flow over a 48-hour period. It was preceded by a dry interval of less than 1 day since the previous storm event. The total precipitation volume and rainfall rate exceeded predictions for the storm and the autosampler had insufficient capacity to capture the entire storm hydrograph based on the flow pacing utilized for the event. Additionally, the storm event generated multiple large runoff peaks above base flow. However, the collected aliquots successfully captured the majority of the largest peak flow event during this multi-peak storm event. Samples were collected on the rising limb of the highest peak storm flow event up to peak flow and a proportion beyond the peak flow on the falling limb of the hydrograph (**Figure 5-10**). Therefore, although only about 45 percent of the entire storm event was captured for conditions above base flow, 91 percent of the event hydrograph for the main storm event peak runoff was sampled by volume (see Table 5-2).

Water Quality Results

The intent of the water quality monitoring within the Canal was to determine whether Canal water quality generally had characteristics typical of urban stormwater and authorized non-stormwater flows for a broad range of constituents (such as nutrients, metals, and bacteria). Documenting the Canal water quality in this manner enabled accurate characterization of baseline water quality conditions for specific water quality constituents. Also, in terms of temperature, DO, and pH, the basis of the 303(d) listing for Lake Merced (described in Chapter 3 in detail) the general approach for water quality monitoring and assessment was to determine if the Canal stormwater and base flow water quality meets or exceeds the existing water quality of Lake Merced.

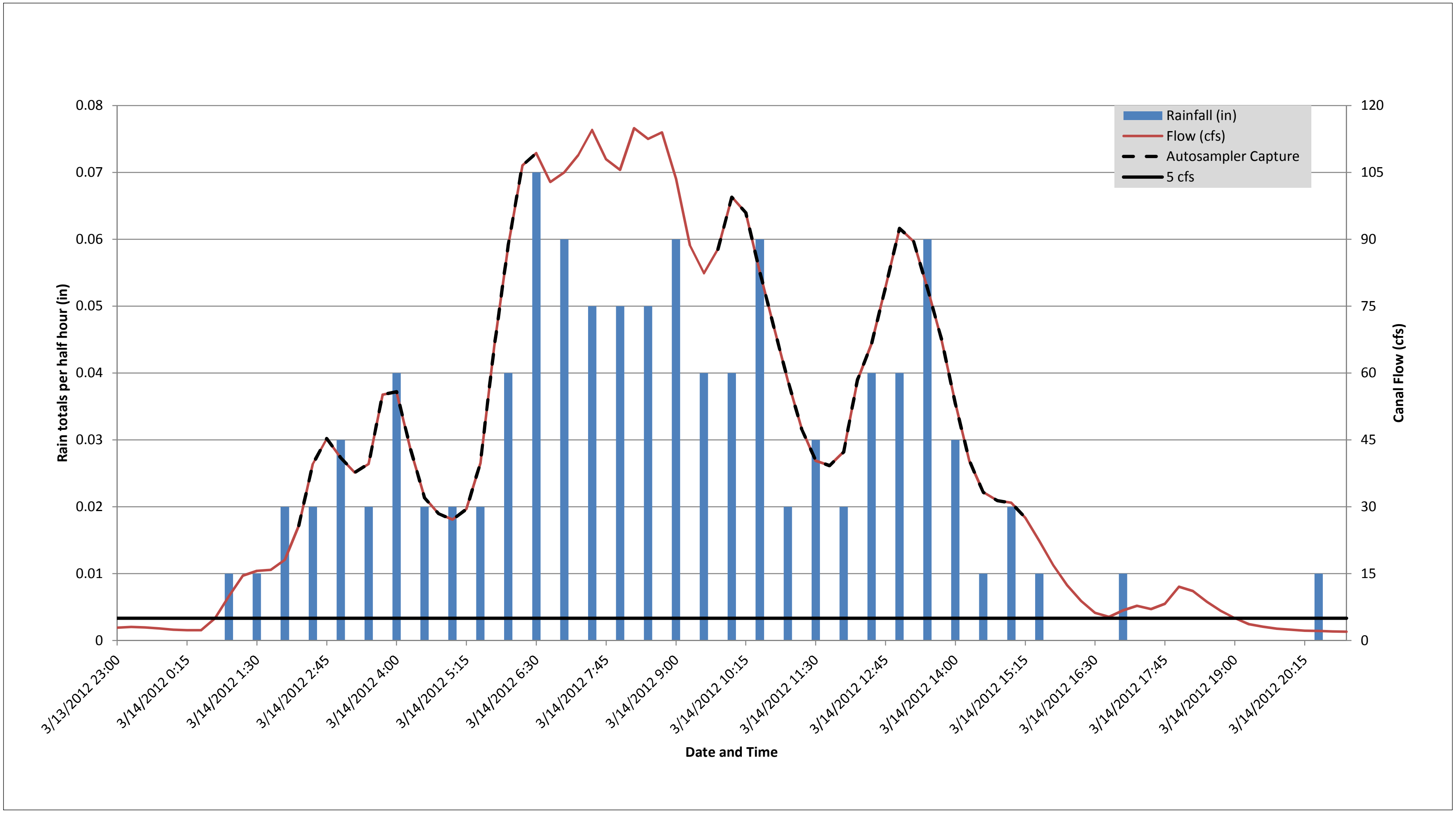
Tables 5-3 and **5-4** present summaries of the dry and wet season water quality data that was collected for the Canal during the 2011-2012 monitoring season. Detailed results of Canal water quality monitoring are included in Appendix B. The following sections discuss the monitoring results for temperature, DO, and pH (summarized in Table 5-3), the focus of the Chapter 6 analysis. Also presented below is a discussion of the water quality results for the broader suite of constituents presented in Table 5-4.

[12] The long duration of the storm allowed staff to reset the autosampler during the storm event and sample collection continued beyond the 48 aliquot sample capacity of the autosampler. However, resetting the autosampler during the storm event meant that a portion of the peak flow was not sampled as part of the composite storm sample.



SOURCE: ESA, 2013

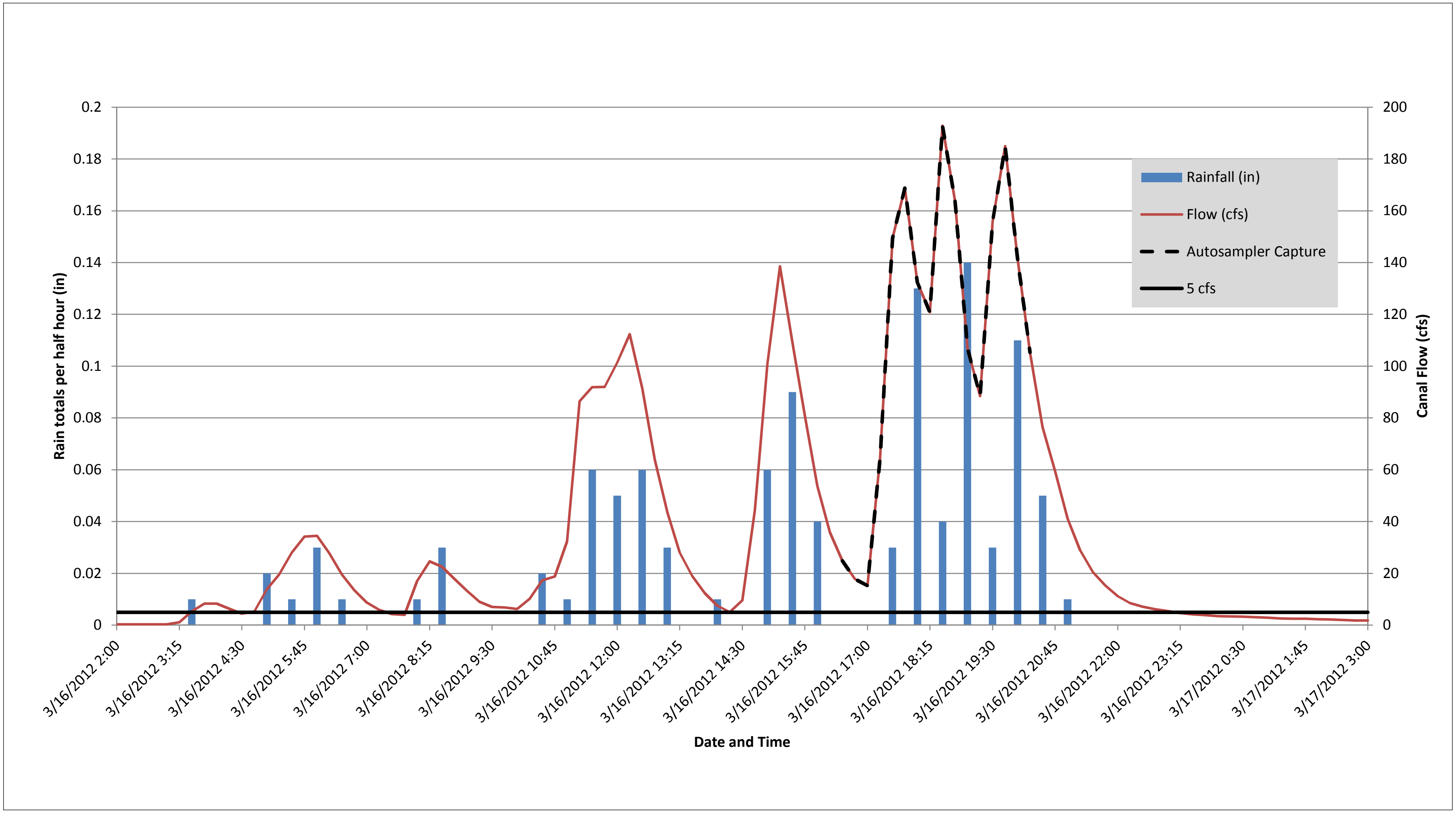
Figure 5-8
March 13, 2012 Storm Hydrograph



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-9
March 14, 2012 Storm Hydrograph



SOURCE: ESA, 2013

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 5-10

March 16, 2012 Storm Hydrograph

TABLE 5-3
VISTA GRANDE CANAL WATER QUALITY DATA SUMMARY

Parameter	Dry Season Base Flow			Wet Season Base Flow			Wet Season Storm Flow		
	Mean	Min	Max	Mean	Min	Max	Mean	Min[a]	Max
Temp (ºC)	17.73	15.6	20.4	14.48	12.2	17.2	13.79	11.09	17.42
DO (mg/L)	12.89	12.07	16.6	11.70	8.41	16.2	10.15	5.83	11.23
pH	8.8	8.7	8.8	8.12	7.3	9.3	7.63	7.1	8.1

NOTES:
[a] Periodically, the stilling well containing the water quality sonde became clogged with fine sediment, causing malfunction. Data associated with such events typically expressed extreme values with rapid transitions between high and low readings. Such events were recorded in field notes and associated data was subsequently flagged and removed from data summaries.

SOURCE: ESA

Dissolved Oxygen and pH Water Quality Results

Overall, the water quality of storm flows in the Canal was similar to that of Lake Merced during the corresponding period in terms of temperature, DO, and pH. Base flows ranged more widely, but are not characterized in detail as part of this assessment as base flow would pass through a constructed treatment wetland before entering Lake Merced. The pH values above 8 and DO values above about 12 mg/L in the base flows are probably a reflection of photosynthesis by benthic (bottom growing) algae that would be exposed to full sunlight conditions within the Canal.

For storm flows exceeding 5 cfs (the minimum flow required to submerge the water quality sonde probes) temperatures and pH levels were generally similar to those in Lake Merced, as would be expected during the colder wet season period. DO levels were generally equal to or higher than those in Lake Merced, as would be expected during the colder wet season and as a result of the turbulent mixing of storm flows in the Canal. Additionally, it is expected that DO and pH levels in Canal stormflows would rapidly equilibrate with the background levels in the Lake depending in large part on weather conditions during and immediately following a given storm event.

Other Water Quality Constituent Results

Approach and Context for Water Quality Results

The concentrations of nutrients, selected metals, and bacteria in Canal base flow and stormwater observed in the 2011-2012 wet season monitoring are summarized in Table 5-4 and discussed below. The intent of this monitoring was to confirm that concentrations of these constituents were generally in the ranges expected for urban stormwater and non-stormwater runoff and that the Canal water was unlikely to have discernible impacts on the Lake. As part of the determination of potential water quality effects to Lake Merced, the consideration of water quality results for a range of constituents must be considered within the context of proposed physical and operational Project elements as well as regulatory controls to urban runoff water quality and hydrologic elements, such as the relative volume of Canal flows as compared to Lake volume.

TABLE 5-4
VISTA GRANDE CANAL 2011-2012 MONITORING DATA SUMMARY

Constituent or Physical Property	Unit	Dry Season Base Flow[a]			Wet Season Base Flow[b]			Wet Season Storm Flow[c]		
		Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median
Nutrients										
Total phosphorous [P]	mg/L	0.15	0.4	0.2	0.16	0.77	0.255	0.12	0.62	0.17
Orthophosphate as P	mg/L	ND (<0.1)[d,f]	0.27[d,f]	0.079[d,f]	0.089[f]	0.42	0.125[f]	ND (<0.1)[d]	0.27	0.12[e]
Nitrate as N	mg/L	3.1	4.7	4.15	2.6	4.9	3.6	0.21	1.1	0.31[e]
Total Kjeldahl Nitrogen (TKN)	mg/L	0.61	1.5	0.875	0.63	2.8	1.65	0.41	4.3	0.70
Ammonia as N	mg/L	0.05[d]	0.32[d]	0.078[d]	ND (<0.05)[d]	0.19	0.117[d]	ND (<0.05)[d]	1.1	0.15[d]
Oxygen Demand										
Chemical Oxygen Demand (COD)	mg/L	17	33	22	10	36	18.5	9.9	57	12[d,f]
Biochemical Oxygen Demand (BOD)	mg/L	ND (<4)[d]	4[d]	4[d]	ND (<4)[d]	4.3	4[d]	ND (<4)[d]	29	4[d,e]
Metals (Total)										
Copper (Cu)	µg/L	4.3	6	5.55	4.9	9.6	6.3	12	59	17.5[e]
Nickel (Ni)	µg/L	4.1	6.6	4.8	5.2	8	7.05	3	12	3.6[e]
Metals (Dissolved)										
Copper (Cu)	µg/L	ND (<0.5)[d]	5[d]	3.35[d]	3.7	8.4	4.35	ND (<0.5)[d]	32	7.7[d]
Nickel (Ni)	µg/L	ND (<0.5)[d]	5.8[d]	4[d]	4.8	7.5	5.65	ND (<0.5)[d]	6.1	1.45[d]
Physical Parameters										
Total Suspended solids (TSS)	mg/L	2.2[e]	34[e]	3.5[e]	2.4[e]	19.2[e]	3.5[e]	4.2	119	21.8[e]
Bacteria/Organisms										
Total Coliform	cfu/100 mL	5,100	140,000	14,900	100[d]	3,100,000	12,200[d]	10000	520000	70,000
Fecal Coliform	cfu/100 mL	120	5,700	980	10[d]	19,000	120[d]	2000	8000	4,900
E. coli	cfu/100 mL	1,000	20,000	3,750	100[d]	10,000	600[d]	10000	200000	10,000[d]
Enterococcus	cfu/100 mL	45	6,300	540	10[d]	16,000	350[d]	4000	42000	14,500
MS-2 (Bacteriophage, Male Specific)	pfu/mL	ND(<1)[d]	322[d]	6.5[d]	ND(<1)[d]	184	20	4	52	25

TABLE 5-4 (Continued)
VISTA GRANDE CANAL 2011-2012 MONITORING DATA SUMMARY

Constituent or Physical Property	Unit	Dry Season Base Flow[a]			Wet Season Base Flow[b]			Wet Season Storm Flow[c]		
		Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median
Bacteria/Organisms (cont.)										
Giardia	cysts/L	ND (<0.1)[d]	3.58[d]	0.23[d]	ND (<0.13)[d]	1.2	0.13	ND (<0.12)[d]	0.12	0.12
Cryptosporidium spp.	oocysts/L	0.1[d]	0.23[d]	0.14[d]	ND (<0.1)[d]	0.13	0.125[d]	ND (<0.13)[d]	0.12	0.12
Bacteroidales - General		Present	Present	-	Present	Present	-	Present	Present	-
Bacteroidales - Human		ND	Present	-	Present	Present	-	ND	Present	-

NOTES:
a Dry season samples were taken on August 17, September 1, September 15, September 30, October 13, and October 27, 2011.
b Wet season base flow samples were taken October 4, 2011 and January 13, January 24, February 6, and February 17, 2012. Note that although the October 4, 2011 base flow sampling event took place during the dry season window (August 15 to October 31), it was included as a wet season sampling event because it occurred after the first storm event of the season on October 3, 2011.
c Wet season storm samples were taken on January 19, January 23, February 28, March 13, March 14, and March 16, 2012.
d One or more samples in the group was Non-Detect
e One or more samples in group have a dilution factor that is greater than DF=1
f One or more samples in this group is J-flagged

SOURCE: ESA

As discussed in the Project Description in Chapter 2 and in Chapter 6, the intent of the proposed project is that both dry season and wet season Canal base flows would be diverted to the constructed treatment wetland before being conveyed to the Lake. Therefore the measured Canal concentrations are not indicative of the base flow concentrations and loadings that would be conveyed to the Lake. Stormwater flows would be conveyed through a 5 mm screening device prior to diversion to the Lake. The screening process would remove trash and constituents associated with larger particles in the stormwater.

The Canal base flows result from a combination of sources within the urbanized Vista Grande watershed. These non-stormwater sources are identified in and are regulated under Provision C.15 of the MRP as Exempted and Conditionally Exempted Non-Stormwater Discharges (see also Chapter 3). Sources include irrigation runoff, car washing, foundation drains, and planned and unplanned potable water system discharges. The MRP specifies required BMPs and monitoring and reporting requirements for these various discharges. The MRP requires that pollutant concentrations in these various discharges be controlled via implementation of applicable BMPs to the Maximum Extent Practicable (MEP). Daly City has an effective stormwater and non-stormwater management program in compliance with the MRP.

While the base flow concentrations of certain constituents in the Canal may at times be higher than background concentrations in the Lake, the overall volume of annual base flow is relatively low. Thus, the concentrations of the individual constituents are less important than the degree of treatment that would be provided by the constructed treatment wetland and the resultant loadings (i.e., volume times concentration) to the Lake after treatment. To assess the effect (Chapter 6), the treated base flow concentrations and the stormwater volume and constituent loadings to the Lake need to be compared to the Lake background concentrations and total Lake volume that these flows would be mixed with. As shown in Table 5-2, flows from the storm events monitored in 2012 each represented less than 1 percent of the Lake volume (5,625 acre-feet). Average base flow volume is estimated at 0.5 acre-feet per day and on a cumulative annual basis represents 0.01 to 0.02 percent of the Lake volume.

Nutrients and TSS

The most important constituent of potential concern monitored in the Canal was TIN, the sum of nitrate and ammonia concentrations. Nitrogen (TIN) is the limiting nutrient in the Lake relative to algal growth, based on review of available information and this analysis. Phosphate is present at levels well above those likely to limit algal growth. While individual and median TIN concentrations are summarized below, it is important to note that the assessment of TIN impacts on algal concentrations (Chapter 6) is based on annual average TIN concentrations. This is due in part to the fact that the majority of Canal TIN inputs would occur during the winter, which includes low light and temperature months that result in low algal growth rate whereas the peak algal growth period does not occur until the late spring, summer, and early fall months. Therefore, it is the accumulated mass of TIN retained within the Lake that controls algal growth, not the input from an individual stormwater diversion event.

The median dry season base flow TIN concentration was 4.3 mg/L TIN (nitrate, 4.2 mg/L, ammonia, 0.08 mg/L). The median wet season base flow TIN concentration was 3.8 mg/L. (nitrate, 3.6 mg/L; ammonia, 0.2 mg/L). Nonetheless, the concentration of nutrients in winter is very variable with periods of higher nutrient concentrations occurring when rains follow a few weeks of dry winter conditions. The median storm flow TIN concentration was considerably lower than the dry and wet season base flow TIN values at approximately 0.5 mg/L (nitrate 0.31 mg/L, ammonia 0.15 mg/L). Rain contains an estimated 0.2 mg/L TIN, diluting the base flow TIN. Potential sources of nitrogen within the watershed include atmospheric deposition, fertilizer in residential irrigation runoff, and illicit animal waste**.**

Lake Merced is already characterized as a eutrophic lake based on long-term algae (chlorophyll a) concentrations in the 23 to 26 ug/L range (Tables 4-3 and 4-4, Section 4.4.2). This analysis considered whether the additional TIN contained in the Canal water would cause excessive algal growth and whether associated impacts on DO and pH would adversely impact Lake beneficial uses. The water quality modeling assessment performed by Dr. Alex Horne (as reported in Chapter 6) indicated that over the range of Lake elevations under consideration, and with the inclusion of a constructed treatment wetland, that the changes in algal concentrations would be minimal. The changes would not be discernible to the human eye and would take many years of monitoring to detect. Algal concentrations could either slightly increase or decrease depending on the design and operation of the constructed treatment wetland. No adverse effects on beneficial uses (i.e., fisheries) were projected based on the additions of Canal water, the increases in Lake elevations, and the associated minor changes in extent of stratification and frequency of mixing events.

Total suspended solids (TSS) rose from median values of 3.5 mg/L in base flows in both summer and winter to 22 mg/L during storm flows (Table 5-4). Most of the constituents monitored tend to be associated with particulates (TSS). As the length of the antecedent dry period before a storm increases, it is expected that the amount of particulates and levels of associated constituents would also increase. However, the existing BMPs (such as street sweeping) reduce the amount of particulate accumulation in this stormwater and therefore, reduce the potential for conveyance into the stormwater system and, in this instance, into the Canal. It is expected that TSS would be removed via settling in the constructed treatment wetland, with larger particulates removed by the debris screening system.

Biochemical and Chemical Oxygen Demand

The concentration of potential oxygen demanding substances in the Canal and Lake was measured as biochemical oxygen demand (BOD) and chemical oxygen demand (COD). BOD measures the oxygen demand of readily oxidizable organic matter and ammonia in a water sample over a five day period. The detection limit for the BOD test is 4 mg/L. COD is calculated through an oxidation test method that also measures the oxygen demand from reduced chemical substances such as sulfides.

To the extent it may be present above background levels, BOD in urban runoff can be derived from naturally occurring organic matter such as leaves, grass clipping, and animal waste. The majority of BOD sampling results both from the Canal and the Lake during all sampling periods were close to or below the 4 mg/L test detection limit. Exceptions occurred during two storm flow sampling events following long antecedent dry periods when BOD values rose to 29 mg/L and 10 mg/L(measured on January 20 and 29, 2012, respectively). TSS and volatile suspended solids (VSS) concentrations were also higher, indicating the more decomposable organic matter had been conveyed into the stormwater system and the Canal during those storm events.

COD values were generally higher than corresponding BOD values. During the dry weather period, COD ranged from 17 to 33 mg/L in Canal base flows as compared to 25 to 34 mg/L in Lake Merced during the corresponding sampling period (Appendix B). During the wet weather period, the range of COD was similar; 12 to 36 mg/L for Canal base flows (Appendix B, page B-63) and <10 to 57 mg/L in Lake Merced (Appendix B, page B-64) on the corresponding sampling dates, potentially representing oxidation of the higher algal biomass present. Higher COD concentrations were also seen in Canal stormflows (as for BOD) during the January 20 and 29, 2012 storm events (99 and 57 mg/L, respectively) as compared to Lake Merced on the corresponding sampling dates (15 and <10 mg/L, respectively).

Overall, BOD and COD levels were relatively low and at consistent levels in the Canal and in Lake Merced during both wet and dry season periods. Neither BOD nor COD concentrations were at levels in the Canal water that would cause discernible decreases in lake water DO concentrations. Canal water would generally be introduced near the surface of the Lake where the highest, sometimes supersaturated DO conditions exist.

Bacteria and Other Microorganisms

As discussed previously, Lake Merced is managed for both recreation and emergency water supply, to be used for sanitary and firefighting purposes, and subject to a boil water order. To protect this latter use, full body contact recreation is not allowed in the Lake. Full body contact recreation such as swimming with head immersion, is the primary pathway whereby humans can be significantly exposed to pathogenic waterborne organisms. Bacteriological water quality objectives were developed based on and intended to protect this full body contact beneficial use. However, because full body contact recreation is not allowed, boating and fishing are the primary uses that could result in incidental exposure to and ingestion of small amounts of Lake water.

The bacterial organisms Total Coliform, Fecal Coliform, E. coli, and Enterococcus are analyzed as indicators of the presence of pathogens, but they are not pathogens themselves. Of these, E. coli is the organism most widely recommended by USEPA for evaluating the microbiological condition of fresh waterbodies. These organisms naturally die off at rates depending on temperature, sunlight (UV) exposure, and predation. They are often associated with particles and therefore subject to removal from the water column by settling. The concentration of organisms in Canal water introduced into the nearshore area of the Lake would also naturally diminish over a short period of time, as discussed below, due to mixing with and transport out into the main water mass of the Lake.

In addition to the indicator organism monitoring, sampling was also conducted for the pathogenic protozoans *Giardia* and *Cryptosporidium*. These protozoans can be transmitted via infected human sources, but more commonly by animal sources. Neither organism was detected in any of the Lake samples. *Cryptosporidium* was detected only once in the Canal (October 13, 2011) and at a level equal to the detection limit (0.1 oocysts/L). *Giardia* was detected during 3 out of 11 Canal sampling events. The highest concentration of 3.58 cysts/L was observed from a dry season event on September 15, 2011. The other two detectable results of 1.2 and 0.23 oocysts/L occurred during wet season base flow sampling on October 4, 2011 and January 13, 2012, respectively.

To further evaluate the likelihood of fecal contamination impacting the Lake and the Canal, analyses were conducted for General Bacteroidales and for Human Bacteroidales. This is a genetic assay test that indicates the presence or absence of fecal related genetic material. The General Bacteroidales test indicates the presence of fecal contamination from any source, and the Human Bacteroidales test indicates the presence of fecal contamination from human activities. This latter test is not specific for only human markers and also detects the presence of fecal material from domesticated animals that share some of the same markers with humans. In this type of urban environment, the results of the Human Bacteroidales test is likely detecting dog fecal matter at least in part. Daly City has a very effective Sanitary Sewer System Management Program so it is unlikely that raw wastewater is a contributing source.

General Bacteroidales were detected in all 15 of the Canal samples and in all 15 of the Lake samples (stations LM-2 and LM-4). Human Bacteroidales were detected in 10 of the 15 Canal samples but in only 1 of the 15 Lake samples (on August 17, 2011 at LM-4). The results indicate that there appears to be widespread contribution to and presence of fecal related material both in the Lake and in the Canal. The potential human component was more limited and could be due at least in part to domestic animals (e.g., dogs) and other wildlife in and around the lake.

Overall, the bacterial and related results indicate that water quality conditions in the Canal are similar to what would be expected in stormwater and authorized non-stormwater flows from a highly urbanized area. The potential impacts from introducing Canal flows into the Lake are considered minimal, given that base flows would be treated through the constructed treatment wetland prior to being introduced into the Lake, that the flows would be introduced near-shore in the Lake, where there is limited potential for full body contact exposure, and that the various microbiological organisms are subject to natural die-off, mixing, and dispersion throughout the Lake that is expected to reduce levels to background conditions within 48 to 72 hours after cessation of stormwater diversions.

Prior to the monitoring conducted for the 2011 and 2012 dry and wet seasons, Daly City and SFPUC established a collaborative effort referred to as the Lake Merced Pilot Stormwater Enhancement Project (EOA, 2011) in support of assessing the feasibility of diverting stormwater runoff from the Canal to the Lake, with respect to various water quality constituents, including bacteriological water quality. Daly City and SFPUC conducted a pilot Canal stormwater diversion project to the Lake during the wet seasons 2003-2004 through 2008-2009 (EOA, 2011). The primary objective of the study was to determine whether the diversion of stormwater increased concentrations of bacterial indicators of human fecal contamination in South Lake, potentially indicating increased human health risk during water contact recreation activities (boating, fishing) in and adjacent to the lake.

The stormwater runoff was treated by a Continuous Deflection System (CDS) and a riparian buffer along the southwestern shoreline of South Lake before conveyance to the lake. Bacteriological water quality monitoring data were collected for treated Canal stormwater and at six near-shore and one background station in the Lake for 17 rainstorm events, with pilot diversions ranging in scale from about 0.1 to 5.4 million gallons per storm event. In general, concentrations of E. coli and Enterococcus were typically reduced by approximately 99 percent (as measured near-shore and at the Lake background station) 48 to 72 hours after cessation of stormwater diversions, as compared to the bacterial concentrations in the CDS treated Canal stormwater. For additional details on this pilot stormwater diversion water quality study as well as water quality results, see Appendix B.

Metals

In the 1990s and early 2000s, wastewater and stormwater management programs placed a significant emphasis on identifying and controlling potential sources of metals to the environment. These programs have been effective in controlling metals sources, particularly copper, to the maximum extent practicable. Copper is the only metal still recognized as a pollutant of concern by the MRP. The copper controls identified in MRP Provision C.13 have been fully implemented for many years by Daly City. The primary remaining source of copper is from vehicle brake pads and legislation has been adopted requiring a progressive reduction in the amount of copper in brake pads.

Other metals, such as nickel and zinc, are generally present at low levels in urban stormwater. It is the dissolved fraction of metals that exert the most toxicity and are the most bioavailable. However, in the presence of organic matter (e.g., ligands) and inorganic constituents such as hardness, the dissolved fraction of most metals, including nickel and particularly zinc, is rapidly converted into less toxic metal complexes. The California Toxics Rule and Basin Plan WQOs are expressed as dissolved metals and as a function of ambient hardness. The WQOs also have both short-term exposure (acute) and long-term exposure (chronic) components. For stormwater, which is generally of a short-term and intermittent nature, typically the acute WQOs are used when evaluating the potential for water quality impacts.

Assuming a conservative ambient Lake hardness of 200 mg/L (as $CaCO_3$), the acute WQOs for lead, copper, nickel, and zinc are 197, 27, 843, and 216 ug/L, respectively. The maximum observed dissolved concentrations in the Canal for these four constituents were 1.6, 32, 12, and 120 ug/L, respectively. The second highest observed Canal dissolved copper concentration was 15 ug/L with other values of as low as <0.5 ug/L. Metals concentrations are almost universally low and available BMPs are already being implemented to maintain these levels and, in the case of copper, further reduce them over time (as brake pad reformulation occurs).

As summarized above, metals concentrations would be expected to be low and, along with other constituents discussed above, would be further reduced in Canal water through treatment in the constructed treatment wetland. Aquatic life beneficial uses currently appear fully protected in the Lake and it is unlikely that the low levels of metals in Canal water would have adverse impacts on beneficial uses. Further, as described for bacteria and other microorganisms above, the Lake Merced Pilot Stormwater Enhancement Project (see Appendix B for additional details), also monitored total metals concentrations in the CDS treated Canal water and in the Lake following diversion events (EOA, 2011). In general, concentrations of total copper that were elevated in the Canal stormwater during diversion events as compared to concentrations in the Lake did not result in copper concentrations in the Lake above background levels (generally non-detect) measured 48 to 72 hours following cessation of a diversion event.

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CHAPTER 6

Water Quality Assessment – Lake Level and Water Quality Modeling Results

This chapter evaluates the possible effects of increasing the mean depth of Lake Merced by approximately 0.5 to 3 feet from the current typical mean annual depth of 6.0 feet (i.e., WSE of 6.5 to 9.5 feet) by the addition of base flow and stormwater from the Canal. Specifically, this section evaluates how project operations may influence future stratification and eutrophication conditions in Lake Merced. In particular, this evaluation focuses on the effects of depth and TIN levels on the two key indicators of Lake "health," algal concentration (chlorophyll a) and Lake clarity (Secchi depth) and the primary factors (e.g., stratification, mixing frequency, TIN levels, extent of constructed wetland treatment) that control them.

There are likely to be two variables that affect Lake Merced health that were estimated using two simple spreadsheet models and assumptions, combined with a quantitative mass balance approach. The first model was based on mixing depth and assessed the effects on chlorophyll a and Secchi depth due to changes in sediment stirring from mixing, and the resultant release of nutrients from the sediments to the water column. The second model assessed the effects of Canal base flow and stormwater on the Lake at various proposed depths, with and without Canal nutrients reduced by use of a basic versus an advanced constructed treatment wetland.

This chapter also provides an assessment of potential effects of increased Lake depths on temperature in the upper mixed layer of the Lake to evaluate the potential for impacts on aquatic life beneficial uses (i.e. fisheries).

6.1 Mixing Model Assessment of Lake Elevation Impacts on Chlorophyll and Secchi Depth

6.1.1 Mixing Depth Model Description

A simple lake model based on mixing depth and the chlorophyll-water transparency relationship was used to estimate the water quality changes that could occur at the range of proposed depth increases. Sediment stirring was used as a proxy for changes in the flux of nutrients to the water. The changes in nutrients were then modeled to show likely effects on chlorophyll a (algae) and water transparency (Secchi depth) that would likely occur at the proposed mean and maximum depths. The results were calibrated against the current Lake conditions and were expressed in terms of potential algae blooms and water clarity.

The mixing model used is based on both theoretical energy-mixing distribution with depth and estimates of the wave length and amplitude in Lake Merced. The continuously recording sonde data from 2011 and 2012 allow this model to build on the predictions from previous ones such as that of Michael Deas (Watercourse Engineering, Davis, CA) used in the EDAW report (2004). That model for Lake Merced was based on the changes of the slope of the thermocline at various wind speeds (Wedderburn or Reynolds's numbers, described on page 8 of EDAW, 2004). Models based on the Reynolds's number use the ratio of wind-powered mixing to the resistance to mixing as determined by the density difference between the warm, less dense upper water layer and the cooler, denser lower layer.

The model used for this assessment was based on the propagation of mixing energy down each surface wave to the sediments (Horne and Goldman, 1994). This model replaces the wind and density differences with empirical data measured or assumed for the Lake; in particular wave length and wave height during windy periods. In large lakes waves vary from place to place but in small lakes such as Lake Merced, these two variables are similar over the 175 acres of surface water. Fully accurate estimates of wave height and length are difficult to measure but an approximate maximum wave height of 30 centimeters (cm) and a wave length of 3 meters (m) were estimated from visual observations at the Lake in 2012.

The oscillation of the water molecules on the surface produces similar, if decreasing, temperature inversions all down the water column. Fewer temperature inversions occur as the water gets deeper and the mixing energy is lost to friction. Temperature inversions cause mixing because they are unstable; cooler denser water is lifted above the surrounding lighter warm water, but due to gravity is then pulled down past its equilibrium depth. If this occurs near the lake bottom, a parcel of sinking water would affect the sediments at an angle, then bounce up carrying with it sediments and nutrients that otherwise would be locked into the mud. The energy propagation with depth method is more direct and more useful for the purposes of estimating sediment nutrient fluxes in lakes with modest depths like Lake Merced than the previous model used (EDAW, 2004).

The water parcel oscillations decrease approximately as the log of the wave length. Thus a 30 cm surface wave would be 3 cm at 3 m (9.8 ft) (i.e., one wavelength) and 0.3 cm at 6 m (19.7 ft) and 3 mm at the bottom of Lake Merced if it was 9 m (29.5 ft) deep. Thus, even during peak wind conditions, oscillations and mixing energy in the deeper areas of Lake Merced are weak relative to that of the surface waters.

There are two kinds of general water motion: waves and currents. Waves are the dominant mixing force due to their vertical component. Currents are the main method of moving water, but have only a small vertical component because almost all of the wind's energy goes into horizontal motion pushing large volumes of the upper water layers around the lake. The Lake can be thought of as a series of separate slabs of water, each a meter or so thick and with a slightly different temperature and density. This Lagrangian Slab concept can be verified experimentally and is useful in determining how mixing energy comes from currents flowing around the Lake. The surface water slab moves quickest and some of its motion is transferred to the next deepest layer.

However, because the Earth is rotating quite rapidly, the Coriolis Force causes the horizontal motion of the lower slab to move to the right at approximately 45 degrees (at equilibrium, which is only reached in large lakes and the oceans). The next slab moves at another 45 degrees and so on down to the bottom in an Ekman Spiral. Thus water moving with the wind at the surface is eventually balanced by other deeper slabs moving in the opposite direction. The friction between each rotating slab does provide a small amount of vertical mixing but this is very small in the deeper slabs due to frictional losses as the huge layers of water slide over each other.

Waves of various kinds provide vertical mixing motion directly and indirectly. The most important is the downward propagation of surface wave energy discussed above. The second is thermocline waves, or seiches, but these are unimportant in Lake Merced because it is not always stratified and the estimated wave lengths in Lake Merced are not long enough to mix deep water. Even with long waves, most seiches' energy is lost as friction when the wave rides over the sediments in shallow edge water. Langmuir Spirals are a combination of the energies of both waves and currents and also mix the lake water. They can be seen as parallel stripes of foam or detritus on stormy days and are oriented in the same direction as the wind. In Lake Merced, as all other waters, the energy of Langmuir Spirals is confined to the upper few meters of water and would have no effect on the bottom. A similar, more efficient wave energy is that of breaking waves on windy days, when parcels of water are ripped from the top of the wave and hurled to the trough of the wave. Again, almost all of this energy is lost on the surface.

The results were calibrated against the current lake conditions using the 2011 detailed temperature sonde data from three depths and were expressed in terms of potential algae blooms (chlorophyll a concentration) and water clarity (Secchi depth).

6.1.2 Mixing Model Results

The effects of increasing the depth of South Lake on lake mixing are shown in **Table 6-1**. The present mixing frequency of 11 days was determined empirically from the output of the continuously recording temperature sondes deployed in 2011. As the Lake depth increased, the mixing frequency decreased because it takes more energy to stir more water. The result in the important variable of mixing is a decrease in the top-to-bottom water column mixing frequency from every 11 days (current situation) to up to 25.5 days (+3.5 feet). The decrease in frequency for the four modeled conditions was not linear because the loss in mixing energy with depth is almost logarithmic.

Based on the summer-fall continuously recording probes deployed in 2011 and some assumptions about wave amplitude and wavelength, the additional water would likely make a noticeable difference in the stratification period. The assumptions for Lake Merced were a typical maximum wave height of 30 cm and a wave length of 3 m. The increase in depth reduces wave-driven swirling on the bottom mud that propagates down from the surface. Bottom stirring would almost halve from 0.1 to 0.04 cm (**Table 6-2**).

TABLE 6-1
MODELED EFFECT OF INCREASING THE DEPTH ON THE FREQUENCY OF MIXING IN SOUTH LAKE

	Present	Scenario A mean	Scenario B mean	Scenario C mean	Scenario C maximum
Depth increase (ft)	**0**	**0.5**	**1.5**	**2.5**	**3.5**
WSE (City Datum, ft.)	6.0	6.5	7.5	8.5	9.5
Water depth (ft)	24	24.5	25.5	26.5	27.5
Depth increase (%)	0	2.1	6.3	10.4	14.6
Mixing frequency (days)	11	12.5	15.0	19.7	25.5
Mixing regime	Polymictic	Polymictic	Polymictic	Polymictic	Moderately polymictic

NOTE: Scenarios A, B, C, and C maximum refer to mean WSE scenarios of 6.5, 7.5, 8.5, and 9.5 feet respectively.

SOURCE: Horne, 2012a

TABLE 6-2
ESTIMATED CHANGES IN BOTTOM WATER WAVE-INDUCED STIRRING WITH ADDITIONAL DEPTH FOR LAKE MERCED

Elevation/Scenario measured	Water depth (ft)	Wave amplitude at depth (cm)
Surface	0	30
Bottom, Existing[a]	24	0.102
Bottom, Scenario A mean (+0.5 ft)	24.5	0.090
Bottom, Scenario B mean (+1.5 ft)	25.5	0.075
Bottom, Scenario C mean (+2.5 ft)	26.5	0.057
Bottom, Scenario C max (+ 3.5 ft)	27.5	0.044
Calibration[b]	18.8	0.36

NOTES:

[a] Depth at WSE 6.0 feet City Datum
[b] Model calibration methods are described in Appendix E.

SOURCE: Horne, 2012a

Some further support for the concept that increasing depth may improve conditions in Lake Merced can be found in the recent Kennedy/Jenks report (2010). This report indicates that a recent increase in water depth (+1.5 ft; 2000 to 2005) resulted in a slight increase in water clarity as measured by Secchi depth. Although the increase was only 8 inches, this is nonetheless an approximately 40 percent improvement over the current water clarity. The recent increased water transparency was not clearly related to nutrients or algae, since these did not change markedly. Nitrate decreased and phosphate increased, with no information given for ammonia. The transparency increase was likely due to less suspended sediment because turbidity declined (Kennedy/Jenks, 2010). A plausible explanation is that deeper water allows slowly sinking sediments to fall below the wind-mixed zone and thus cease to contribute to reduced lake water clarity. Another possible reason is that the new higher water level results in a shoreline less prone to wind-induced soil erosion.

Effects of Reduced Mixing on Nutrients and Algal Biomass

In order to estimate the effects of mixing and nutrients on algal growth, the concentration of nutrients in the Lake during the nutrient-limited period is needed. A summary of the concentration of nutrients in the waters of Lake Merced in the dry season are shown in **Table 6-3**. As shown, nitrogen is relatively low (mean TIN = 93 µg/L) compared to phosphorus (mean TP = 120 to 200 µg/L).

TABLE 6-3
WATER QUALITY DATA FOR LAKE MERCED DURING THE DRY SEASON

Nutrient[a]	Concentration (µg/L)			Comments
	Mean	Max.	Min.	
Nitrate	43	70	19	Very low[b]
Ammonia	50	140	< 50	Low[b]
TIN	93	210	69	Low[b]
TKN (organic-N)	875	1,500	610	Moderate[b]
TN (TKN + nitrate) (approximate)	910	1,600	630	Moderate[b]
Phosphate	35	120	21	High[b]
TP	120	670	210	High[b]
0.8 TP	96	536	168	
TP (2000 to 2003)	200	-	-	High[b]

Ratios of TIN:0.8TP for Lake Merced and Comparison Values

Lake/Scenario	Ratio of TIN:0.8TP	Comments
Lake Merced	1:7.8	Strong N-limitation
Balanced growth	approximately 10:1	No limitation
Lake Superior, Great Lakes	approximately 40:1	Strong P-limitation

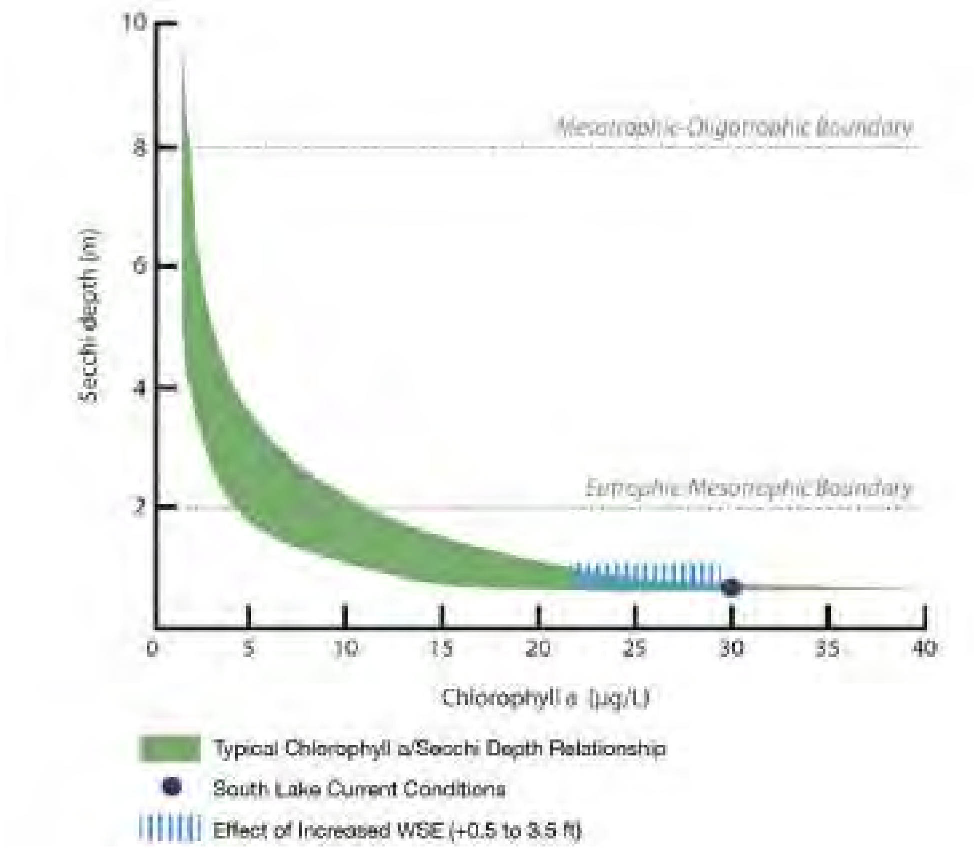
NOTES:

[a] Unless otherwise noted, data are from 2011
[b] Nutrient level compared to what would be expected for an urban water body

SOURCE: 2011 data (complete citation); Kennedy/Jenks, 2010; Casteel et al., 2005

For Lake Merced, the model assumes that the less frequent mixing in the deeper lake scenarios would result in relatively less nutrients stirred up from the bottom and consequently less algae growth and eutrophication. The number of days between mixing events indicates the frequency at which nutrients released from anoxic sediments during temporary stratified conditions are circulated up to the illuminated waters and become available to algae. Thus, the mixing frequency approximates to the eutrophication potential.

The decrease in light attenuation in water is non-linear so in more eutrophic lakes the human observer on the shore has difficulty in seeing an increase in water clarity even when chlorophyll declines substantially (**Figure 6-1**). Once a certain threshold is reached however, relatively small changes in the amount of algae produce observable benefits to the shoreline observer. The lake water is at least potentially nutrient-limited, with nitrate being the limiting nutrient, at least in terms of biologically available nutrients. The effects of decreased nutrients caused by lower sediment mixing due to higher water levels should have an effect on eutrophication, algae, and water clarity. The changes in nutrients caused by simple changes in mixing are assumed to have a linear relationship. The relationship of nutrients to algae, however, would not be one to one (nitrogen released all going to algal growth) since there is considerable inefficiency in converting nutrients in the water to algal biomass.



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SOURCE: ESA; Horne, 2012a

Figure 6-1
Relationship of Algae as Chlorophyll and Water Clarity as Secchi Depth for Lake Merced at Proposed Depth Increases

The estimates of algae (chlorophyll a) and water clarity (Secchi depth) modeled from the changes in mixing were calculated in a simple Excel spread sheet model and summarized in **Tables 6-4** and **6-5**. The basic assumptions for Lake Merced were

- The decrease in sediment stirring by the propagated surface water wave at each greater depth is directly proportional to the amount of nutrient released
- The amount of nutrient released is related to the amount of algae produced according to the empirically deduced factor: 1 µg/L chlorophyll a produced by 7.3 µg/L TIN (from observed decline of TIN in spring and concomitant increase in chlorophyll a)
- Chlorophyll and water clarity related in a curvilinear fashion as found in most other non-muddy, eutrophic lakes

TABLE 6-4
ESTIMATES OF EFFECTS OF INCREASED DEPTHS ON CHLOROPHYLL FOR LAKE MERCED

Elevation/Scenario	Water depth (ft)[a]	Polymictic Index (2011 = 100)	Estimated TIN in mixed water column (µg/L)	TIN decrease (µg/L)	Estimated chl *a* at surface (µg/L)	Chl *a* decrease (µg/L)
Surface	0		90	0	30	
Bottom, Present	24	100	90	0	30	0
Bottom, Scenario A mean (+0.5 ft)	24.5	88	79	11	28.5	1.5
Bottom, Scenario B mean (+1.5 ft)	25.5	73	66	24	26.7	3.3
Bottom, Scenario C mean (+2.5 ft)	26.5	56	50	40	24.5	5.5
Bottom, Scenario C max (+ 3.5 ft)	27.5	43	39	51	23.0	7.0

NOTE: The mean Secchi depth for Lake Merced in 2009 was approximately 2 feet and corresponded to a dry season algal chlorophyll *a* value of 30 µg/L (2000 to 2003 data). This is similar to the long-term data set [chlorophyll *a* 27 µg/L and Secchi depth 1.8 ft (1997 to 2008)]. The TIN in summer is 90 µg/L.

SOURCE: Horne, 2012a

TABLE 6-5
ESTIMATES OF EFFECTS OF INCREASED DEPTHS ON WATER CLARITY FOR LAKE MERCED

Elevation/Scenario	Estimated chl *a* at surface (µg/L)	Estimated Secchi depth (ft)	Eutrophication estimates
Surface	30	2	Eutrophic, no visible changes
Bottom, Existing	30	2	Eutrophic, no visible changes
Bottom, Scenario A mean (+0.5 ft)	28.5	2	Eutrophic, no visible changes
Bottom, Scenario B mean (+1.5 ft)	26.7	2	Eutrophic, no visible changes
Bottom, Scenario C mean (+2.5 ft)	24.6	2 to 2.3	Eutrophic, possible slight increase in water clarity
Bottom, Scenario C max (+3.5 ft)	23.0	2 to 2.3	Eutrophic, possible slight increase in water clarity

For Lake Merced, the empirical data shows the average summer chlorophyll a was 30 µg/L (2000 to 2003; Casteel et al., 2005) and 27 µg/L (range 4.7 to 100; Kennedy/Jenks, 2010). The two values of 27 and 30 µg/L are virtually the same and within the natural variation. For this analysis, 30 µg/L was used rather than 27 µg/L since it is slightly more conservative from the viewpoint of predicting future algal concentrations.

For the 2.5 feet WSE increase, an estimated decrease of 40 µg/L is TIN is predicted with a resulting decrease in algal chlorophyll a of 4.5 µg/L (Table 6-4). The decrease in chlorophyll a is based on measured changes in chlorophyll in Lake Merced with measured changes in TIN. This is described further in the Increase in Algae Due to Stormwater Inflow section below.

The various depth increases produced estimated chlorophyll a reductions of up to 7 µg/L (about 23 percent). A maximum decrease of 23 percent in algae would result in only a small decrease in BOD in the sediments since not all algae sink as complete cells. Thus, the maximum increase in depth would not be a cure for the bottom water low DO episodes.

In terms of water clarity, no effect can be expected even though chlorophyll is estimated to drop with increased depth. There is no water clarity improvement in proportion to lower chlorophyll levels at these concentrations since the curve of chlorophyll with clarity is flat at this algae concentration (Figure 6-1). Because of the shape of the chlorophyll/water clarity relationship, no discernible change in water clarity occurs over the chlorophyll a range of about 16 to 38 µg/L. It is unlikely that anyone could see such a small change and clarity (as determined by Secchi depth measurement) of 2 to 2.3 feet are indicative of less desirable water quality.

6.1.3 Mixing Model Summary and Conclusions

A simple lake model based on mixing depth and the chlorophyll-water transparency relationship was used to estimate the water quality changes that could occur at the range of proposed depth increases. Increased thermal stratification due to increased depth is expected to produce an overall improvement in water quality that would be progressive with increases in depth. The effects of increasing the depth of South Lake on lake mixing are shown in Table 6-1. As the Lake depth increases, the mixing frequency decreases, resulting in a decrease in the top-to-bottom water column mixing frequency from every 11 days (current situation) to up to 25.5 days (+3.5 feet). The less frequent mixing in the deeper Lake would result in relatively less nutrients stirred up from the bottom and consequently less algae growth and eutrophication. With less frequent mixing, the modeled range of depth increases produced estimated chlorophyll a reductions of up to 7 µg/L (about 23 percent; Figure 6-1 and Table 6-4). A maximum decrease of 23 percent in algae would result in a small decrease in algae-related BOD in the sediments, and while some long-term reduction in oxygen depletion in the bottom waters is therefore likely, periods of anoxia would remain during stratified conditions. There would be no likely visible change in water clarity with a predicted Secchi depth increase of only 2 to 2.3 feet because of the flat shape of the chlorophyll/water clarity relationship at these levels (Figure 6-1).

6.2 Methodology to Assess Canal Base Flow and Stormwater Effects on Lake Merced

A spreadsheet model was used to assess the effects of Canal base flow and stormwater diversions to the Lake at various proposed depths and with and without nutrients reduced by use of two types of constructed treatment wetland. The model assumptions are:

- Inflowing Canal water nutrients are completely mixed with over-winter Lake nutrients.
- The early spring concentration of the limiting nutrients (TIN) controls the maximum summer-fall chlorophyll concentration.
- One µg/L of chlorophyll would result from 7.3 µg/L of TIN based on an empirical relationship made using Lake Merced data.
- The effect of the increased TIN additions from Canal diversions would show over the five algae blooms that normally occur in Lake Merced.
- The resultant Canal diversion TIN increases are combined with the reductions in TIN expected from the water depth increases.
- TIN removal from a basic wetland design assumed a conceptual design with one or more ponds with reeds around and with a random assortment of unplanted vegetation.
- TIN removal from an advanced wetland design assumed a conceptual design with 4 to 5 cells to minimize short-circuiting and planted with specific kinds of vegetation.
- The constructed treatment wetland would reduce N-inflows during the summer (a conservative assumption with no acknowledgement of reductions that could occur in winter if wetland water residence time is extended).

6.2.1 Model Description

The detailed calculations to predict the effects of various volumes of stormwater needed to increase lake levels +0.5 to +3.5 feet were made using a spread sheet model and are summarized in Table 6-8. To estimate the preliminary potential effects, the change in nutrient concentrations and resulting change in algae concentrations were analyzed for the filling period when the lake level is raised to the target WSE, and for the steady state period when smaller annual contributions are made to maintain the target WSE range.

6.2.2 Effects of Increased Nutrient Loading from Canal Base Flow and Stormwater on Algal Biomass

At present, Lake Merced is a terminal lake with no direct outflow to the sea. An indirect outflow exists as described above at the overflow to the Canal situated at an elevation of 13 feet City Datum. Thus, any water entering the Lake would either dilute or concentrate nutrients in the water depending on its nutrient concentration, unless the WSE exceeds 13 feet City Datum, as it has not done since 1942 (SFPUC, 2011b). Since the Lake currently receives no inflow from surface runoff in the dry season, and an unknown but very small amount of inflow from groundwater (see Figure 4-2), the amount of nutrients already present in the Lake in late winter and early spring would determine the amount of algae that would grow between March and November.

The project would result in water flows from the Canal to the Lake during summer (base flows) and winter (base and storm flows) to increase its depth. Nutrients in base and storm flows from the Vista Grande Canal have the potential to slightly affect the level of eutrophication in Lake Merced. On average, stormwater in winter 2012 contained moderate amounts of nutrients (**Table 6-6**). Median TP was 270 µg/L. TIN, the sum of nitrate as nitrogen (420 µg/L) and ammonia as nitrogen (190 µg/L), was 610 µg/L. Comparatively, Canal base flow in winter 2012 had a similar median TP of 255 µg/L, but a higher median TIN of 3,700 µg/L. In comparison, Lake Merced water at this time had a TP concentration of 150 µg/L but a much lower concentration of TIN (90 µg/L) than the incoming stormwater. This is not surprising, since Lake Merced is strongly TIN-deficient and TP-rich, relative to many U.S. waters located in cooler, wetter climates. The potential effects are based on the assumption that the majority of TIN added during stormwater diversion events remains in the water column and is available in a suitable form for direct algae uptake and growth during the seasonal peak growth period. As described in Section 4.4.2, this is a simplifying and conservative assumption, given that there are multiple nitrogen removal processes occurring concurrently within the Lake, in the bottom sediments, and along the shoreline, including denitrification and uptake by aquatic plants.

TABLE 6-6
KEY NUTRIENT LEVELS IN THE VISTA GRANDE CANAL

Constituent	ESA 2011-2012 Monitoring Data							Kennedy/Jenks Consultants, 2009[a]		EDAW, 2004[b]
	Base Flow			Initial Storm Flow	Storm			Base Flow	Storm	
	Min	Max	Median		Min	Max	Median			
Ammonia - as N (mg-N/L)	0.05	0.19	0.117	0.07	0.09	1.1	0.19	1.7	0.7	0.7
Nitrate (mg-N/L)	2.6	4.9	3.6	3.56	0.21	1.1	0.42	4.23 (mg/L)	3.77 (mg/L)	2.3
Total Nitrogen (TN) (mg-N/L)	--	--	--	--	--	--	--	--	1.89 – 34.8 (mg/L)	6.7
Total Kjeldahl (TKN) Nitrogen (mg/L)	0.63	2.8	1.65	8	0.41	4.3	1.11	--	--	--
Total Phosphorus (TP) (mg-P/L)	0.16	0.77	0.255	1.6	0.12	0.62	0.27	--	0.547 (mg/L)	1.0

NOTES:

a Kennedy/Jenks Consultants. 2009. *San Francisco Water System Improvement Project: Lake Merced Water Levels Restoration (CUW30101) Draft 100% Conceptual Engineering Report*, Prepared for San Francisco Public Utilities Commission, January 2009. [some of the data from CH2M Hill, 2004. *Vista Grande Canal Lake Merced Pilot Storm Water Treatment Project, Technical Memorandum 3*, Table 2)

b EDAW. 2004. *Lake Merced: Initiative to Raise And Maintain Lake Level and Improve Water Quality: Task 4 Technical Memorandum*, Prepared for the San Francisco Public Utilities Commission, September 2004. [used data from SFPUC 2000-2003 monitoring]

SOURCES: ESA; Kennedy/Jenks Consultants, 2009; EDAW, 2004.

Under certain conditions for the proposed project, here defined as the initial storm flow event for the wet season, the concentrations of both TP and TIN in the stormwater could increase to 12 (TP) and 22 (TIN) times the concentrations in the Lake water (**Appendix B**). This flow is important because it contains higher nutrient concentrations than subsequent storm flows. Even though the volume of stormwater from individual storm events is relatively small compared with that of the Lake at the time of winter storms (typically less than one percent of lake volume), the potential input from the initial storm flow, if diverted to the Lake, could disproportionately increase nutrient concentrations in the Lake, leading to increased algal growth later in the year, assuming as noted above that all the added TIN remains present and bioavailable.

Algae can use either nitrate or ammonia, so TIN is a convenient summary of the eutrophication effects of added stormwater. In any event, ammonia arriving at the Lake would probably be rapidly oxidized to nitrate before uptake since winter algal growth is limited by the weak sunlight. Particulate matter would sink to the bottom in the Lake and not necessarily affect free water concentrations, especially under the fully oxidized winter conditions.

Over winter, the nutrients in Lake Merced build up due to releases from the sediments, groundwater, and any surface water inflows, as well as from direct precipitation and dust settling on the lake surface. As winter turns to spring, the nutrient concentrations begin to fall as algae grow and use them up (**Table 6-7**). In particular, TIN reached 120 µg/L on January 23, 2012 then fell to 40 µg/L by March 13. Using this empirical data from late fall to spring 2012, a maximum decline of about 80 µg/L of TIN (120 minus 40 µg/L of nitrate + ammonia) occurred. Since nitrogen is the potential limiting nutrient for algal growth, it is likely that the 80 µg/L of TIN taken up became incorporated into phytoplankton during the "spring" blooms of algae.[13] In addition, although algal growth is low in winter due to low light, there is sufficient illumination for some growth and algae can take up some nutrients and store them for later use.

TABLE 6-7
CHANGES IN NUTRIENTS IN THE LAKE AND IN STORMWATER MEASURED OVER WINTER IN LAKE MERCED IN 2012

Nutrient (µg/L as N or P)	Jan 20	Jan 23	Feb 29	Mar 13
Lake				
TP	150	140	110	100
Nitrate-N	20	70	20	10
Ammonia-N	50	50	50	30
TIN	70	120	70	40
Stormwater				
TP	620	170	360	180
Nitrate-N	1,100	210	260	580
Ammonia-N	1,100	50	210	170
TIN	2,200	260	470	350

SOURCE: Horne, 2012a

13 The terms spring, summer, and fall phytoplankton blooms were coined by temperate zone limnologists, and in lower latitudes, the spring bloom is often a late-winter growth.

The average increase in chlorophyll from wet (winter) to dry (summer) season over the years is 11 µg/L (30 minus 19 µg/L, Kennedy/Jenks Consultants, 2010) and the average uptake of TIN in early spring was described in the previous paragraph to be 80 µg/L. Thus, 1 µg/L chlorophyll a is grown by the decrease of 7.3 µg/L TIN (80/11). This value can be used to predict the amount of algae that would grow given a known amount of TIN added in stormwater. The 1 to 7.3 relationship is not a directly causal relationship since it was empirically derived and accounts for direct uptake of TIN for algal growth but also the losses of algae by sinking to the bottom, grazing of algae by zooplankton at the time, and any parasitism that may have occurred possibly due to chytrid fungal attacks.

6.2.3 Nutrient Loading Model Results

Filling Period

To assess how inputs of nutrients in storm and base flows could affect algal growth, nutrient effects during the winter (5-month) and summer (7-month) periods were analyzed individually and then combined to assess the annual average change in algae concentration. **Tables 6-8**, **6-9**, and **6-10** provide a summary of the estimated net effects of increases in water depth, storm nutrient inflows (TIN = 610 µg/L) and year-round base nutrient flows (TIN = 3,700 µg/L) to Lake Merced under three different filling schedules, and with and without two types of proposed constructed treatment wetland. The design of the proposed wetland is in progress; therefore, this analysis considers two possible constructed treatment wetland types to show a range of potential water quality predictions post treatment; one that provides some treatment and settling and follows a simple design approach that is self-regulating (basic) and one that provides more substantial water quality treatment through a greater degree of design with multiple cells planted in a manner to facilitate specific constituent removal (advanced).[14] The filling times presented assume that storm flows below 35 cfs would continue to be diverted to the Pacific Ocean. The impacts of alternative diversion flow thresholds are discussed in Chapter 2 (Project Description). In general, the higher the diversion threshold selected, the longer time it would take to fill the Lake to the desired water surface elevation and reach a steady state elevation condition.

Table 6-8 summarizes the potential change in winter TIN, Table 6-9 summarizes the potential change in summer TIN, and Table 6-10 summarizes the net change combining summer and winter TIN and net effects on algal concentrations. All potential changes in chlorophyll values are based on the current mean annual concentration of 30 µg/L.

Without the Proposed Constructed Treatment Wetland. Potential effects on algal growth were analyzed without the proposed constructed treatment wetland for comparative purposes. Without the constructed treatment wetland, the net result is that at all rates of filling, there would be an estimated increase of 8.1 to 11 µg/L (mean 9.7 µg/l) of chlorophyll a in summer in the Lake to give mean summer values of 38 to 41 µg/L compared with the current mean of 30 µg/L. The

[14] **Appendix G** includes general concepts and examples related to basic and advanced wetland types.

TABLE 6-8
ESTIMATED NET EFFECTS ON WINTER TIN DURING FILLING PERIOD

Max WSE (ft)	Flow Diversion Threshold (cfs)	Average Filling Time (Months)	Winter Nitrate or TIN (µg/L)						
			In Base Flow	In Storm Flow	Current in Lake Winter	After Storms inc Base + Storm Flows	Winter Increase	Depth Reduction Effect	Net Winter Increase
No wetland									
7.5	> 35	17	3700	610	90	175	85	-24	61
8.5	> 35	30	3700	610	90	185	95	-40	55
9.5	> 35	42	3700	610	90	182	92	-51	41
Basic wetland									
7.5	> 35	17	1000	610	90	125	35	-24	11
8.5	> 35	30	1000	610	90	138	48	-40	8
9.5	> 35	42	1000	610	90	136	46	-51	-5
Advanced wetland									
7.5	> 35	17	500	610	90	116	26	-24	2
8.5	> 35	30	500	610	90	129	39	-40	-1
9.5	> 35	42	500	610	90	128	38	-51	-13

SOURCE: Horne, 2012c

TABLE 6-9
ESTIMATED EFFECTS OF STORMWATER NUTRIENT INFLOWS TO LAKE MERCED WITH WINTER 2011-2012 NUTRIENT CONCENTRATIONS DURING FILLING PERIOD

Max WSE (ft)	Volume of water added (L x 10^6)	TIN added (µg x 10^9)	TIN present before storm (µg x 10^9)	Final TIN at end of wet season (µg x 10^9)	TIN increase (µg/L)	Estimated chl a change (µg/L)
+ 0.5	99.9	46	234	104	13.7	1.9
+ 1.5	300	138	234	128	38.3	5.2
+ 2.5	500	230	234	150	59.7	8.2
+3.5	700	322	234	169	78.5	10.7

SOURCE: Horne, 2012a

TABLE 6-10
ESTIMATED NET EFFECTS ON SUMMER TIN, COMBINED SUMMER AND WINTER TIN, AND ALGAL CONCENTRATIONS DURING FILLING PERIOD

Max WSE (ft)	SUMMER: Nitrate or TIN (µg N/L)				Summer and Winter (µg N/L)	Algae (µg Chl/L)		
	Increase in Base Flow	Depth Reduction Effect	Usable Over Summer Baseline	Mean Usable For 5 Blooms	Net Increase	Net Effect	Conc. in Lake	Change (%)
No wetland								
7.5	96	n/a	96	19	80	11.0	41	37
8.5	95	n/a	95	19	74	10.1	40.1	34
9.5	92	n/a	92	18	59	8.1	38.1	27

TABLE 6-10 (Continued)
ESTIMATED NET EFFECTS ON SUMMER TIN, COMBINED SUMMER AND WINTER TIN, AND ALGAL CONCENTRATIONS DURING FILLING PERIOD

Max WSE (ft)	SUMMER: Nitrate or TIN (µg N/L)				Summer and Winter (µg N/L)	Algae (µg Chl/L)		
	Increase in Base Flow	Depth Reduction Effect	Usable Over Summer Baseline	Mean Usable For 5 Blooms	Net Increase	Net Effect	Conc. in Lake	Change (%)
Basic wetland								
7.5	25	-24	1	0	11	1.5	31.5	5
8.5	25	-40	-15	-3	-4	-0.5	29.5	-2
9.5	24	-51	-27	-5	-10	-1.4	28.6	-5
Advanced wetland								
7.5	12	-24	-12	-2	0	-0.1	29.9	0
8.5	12	-40	-28	-6	-7	-0.9	29.9	-3
9.5	12	-51	-39	-8	-21	-2.8	27.2	-9

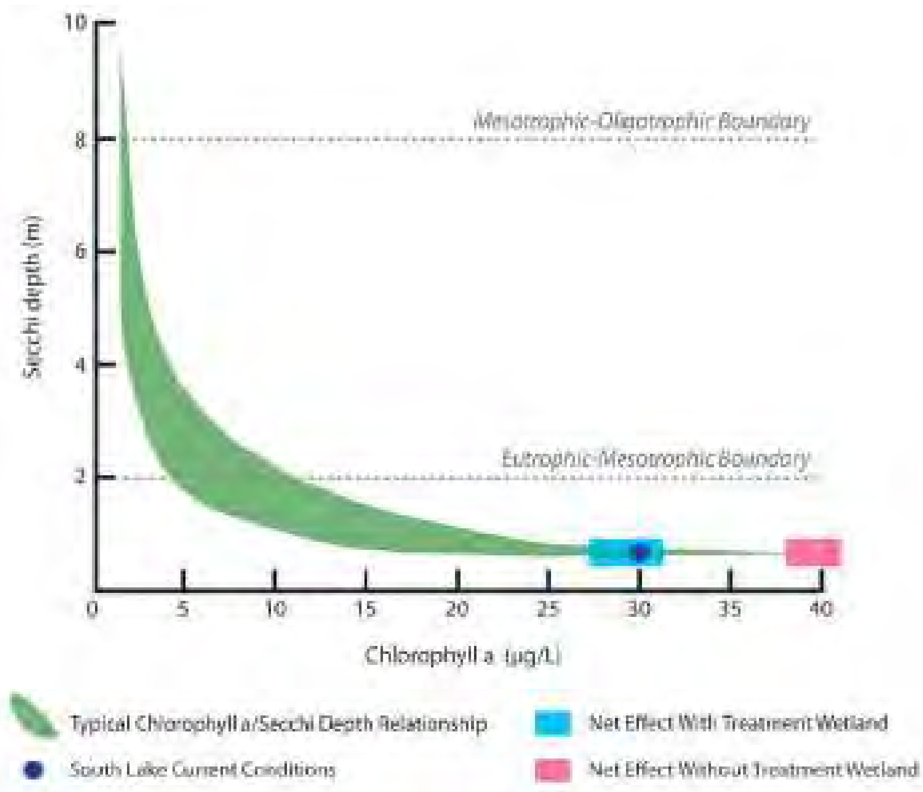
NOTE: No depth reduction allowance was made for the no-wetland option in summer since the out-flowing water would be warm and thus not sink to the bottom as would cool wetland outflow.

SOURCE: Horne, 2012c

average of 32 percent increase in algae is about that which would be analytically detectable from background over a few years. Smaller increases or declines would be obscured by natural seasonal and other variations.

The chlorophyll increase would likely have an effect on the bottom DO concentrations – probably by making periods of low DO longer than at present. However, the change of about 10 µg/L in chlorophyll would not be noticeable to the public in terms of water clarity since all changes fall on the flat section of the Secchi depth-chlorophyll a curve where any lake visually appears about the same shade of green once chlorophyll levels are above about 15 µg/L (see **Figure 6-2**). Edge blooms of blue-green algae, which float and thus concentrate at the surface, could be more visible to the public. However, this edge scum is at times already present in the Lake and so the difference would be subtle since the wind direction and speed on the day of observation is the dominant force in the size of the edge scums. Figure 6-3 presents the net TIN changes for the scenario that does not include a proposed constructed treatment wetland. Figure 6-4 presents the net effect on Lake chlorophyll a concentrations during the filling period for the scenario that does not include a proposed constructed treatment wetland.

With the Proposed Constructed Treatment Wetland. With operation of either of the proposed constructed treatment wetland conceptual designs, the proposed flows would likely result in minor increases or decreases in the chlorophyll concentration of the Lake. The main purpose of the wetland would be to reduce nitrate in the stormwater and especially in the summer base flow, which contains elevated concentrations of nitrate relative to those present in the Lake in summer, although the base flow volumes are considerably lower than storm flows (again depending on the diversion threshold flow selected). Depending on the details of the design and operation of the



SOURCE: Horne

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Figure 6-2
Potential Effects on Chlorophyll A and Secchi Depth

wetland, the changes would range from an estimated increase of about 1.5 µg/L (5 percent increase) to an estimated decrease of up to 2.8 µg/L (9 percent decline) in the Lake chlorophyll concentration (Figure 6-2). The kind of plants in the wetland, air temperature, and the actual area of the treatment wetland (i.e., excluding berms) would influence the actual drop or slight rise in algae. Again, this small change would not be noticeable to the public and as a statistically significant trend would also be difficult to detect. Figure 6-3 presents the net TIN changes during the filling period under the basic and advanced wetland treatment scenarios. Figure 6-4 presents the net effect on Lake chlorophyll a concentrations during the filling period under the basic and advanced wetland treatment scenarios.

Steady State

After the Lake reaches the target WSE at the end of the filling period, smaller annual contributions from the Canal would be required to raise the Lake to the maximum WSE each year. As shown in **Table 6-11**, without the proposed treatment wetland, it is estimated that the steady state would undergo an increase of about 6 µg/L algal chlorophyll (19 percent increase). With the treatment wetland, under all conditions, there could be a slight decrease in algae of 1.8 to 3.0 µg/L (6 to 10 percent decrease). Final in-Lake concentrations of algal chlorophyll could be approximately 27 to 35.9 µg/L, depending on the wetland design. Figure 6-5 presents the net effect on Lake chlorophyll a concentrations during the steady state period under the basic and

TABLE 6-11
ESTIMATED NET EFFECTS ON WINTER, SUMMER, AND YEAR-ROUND TIN AND ON ALGAL CONCENTRATION AT STEADY STATE

TIN (µg N/L)									Algae (µg Chl/L)	
Winter Inflow	Winter Increase	Winter Depth Reduc-tion Effect	Winter Net Increase	Summer Net Increase	Summer Depth Reduc-tion Effect	Summer Usable Over Back-ground	Mean Sum Over Back-ground for 5 Blooms	All Year Increase	All Year Net Increase	All Year Value In Lake
No wetland										
158	68	-40	28	74	0	74	15	43	5.9	35.9
Basic wetland										
121	31	-40	-9	20	-40	-20	-4	-13	-1.8	28.2
Advanced wetland										
114	24	-40	-16	9	-40	-31	-6	-22	-3.0	27.0

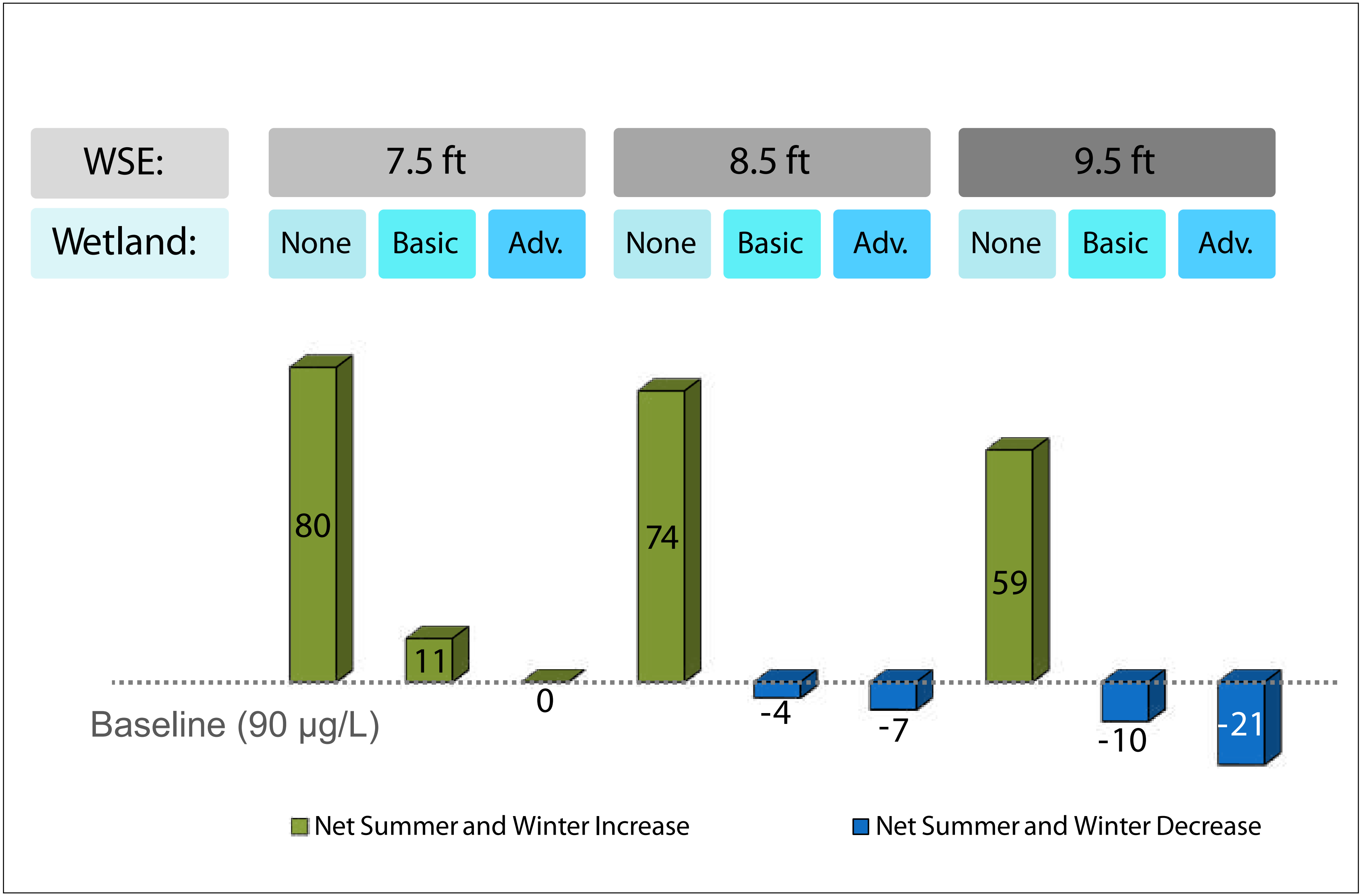
SOURCE: Horne, 2012c

advanced wetland treatment scenarios. It is possible that conditions would further improve over time as internal loading due to dead spring bloom algae is reduced, thereby decreasing BOD loading to the sediments. As with the filling scenario, no change in water clarity would be perceptible to the public for many years. It is possible that the public would perceive some decrease in shoreline blue-green algal scums in the late summer and fall. Thus, at steady state with either treatment wetland design, less mean annual algae than is currently observable could be expected.

6.2.4 Nutrient Loading Model Summary and Conclusions

Nutrient effects during the winter (5-month) and summer (7-month) periods were analyzed individually and then combined to assess how inputs of nutrients in storm and base flows could affect algal growth in Lake Merced, with and without two types of proposed constructed treatment wetland under three different filling schedules. In general, the higher the diversion threshold selected, the longer time it would take to fill the Lake to the desired water surface elevation and reach a steady state elevation condition.

Algae can use either nitrate or ammonia, so TIN is a convenient summary of the eutrophication effects of added stormwater. Without the constructed treatment wetland, the net result is that at all rates of filling there would be an estimated increase of TIN of 59 to 80 µg/L (as compared with the current baseline of 90 µg/L; Table 6-8) available for algal growth (Table 6-10). Depending on the details of the design and operation of the wetland the proposed flows would likely result in minor increases or decreases in the TIN concentration in the Lake, with changes ranging from an estimated increase of 11 µg/L to an estimated decrease of up to 21 µg/L (Table 6-10) (**Figure 6-3**).



SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 6-3
Filling Period Summer and Winter TIN (µg/L)

The net effects on algal concentrations from inputs of nutrients in storm and base flows would depend largely on the details of the design and operation of the treatment wetland. Without the constructed treatment wetland (worst case scenario), the net result is that at all rates of filling, there would be an estimated increase of 8.1 to 11 µg/L of chlorophyll a in summer in the Lake to give mean summer values of 38 to 41 µg/L (as compared with the current mean of 30 µg/L). The average of 32 percent increase in algae is about that which would be analytically detectable from background over a few years. The chlorophyll increase would likely have an effect on the bottom DO concentrations – probably by making periods of low DO longer than at present. With operation of the proposed constructed treatment wetland, the proposed flows would likely result in minor increases or decreases in the chlorophyll concentration of the Lake. Depending on the details of the design and operation of the wetland, the changes would range from an estimated increase of about 1.5 µg/L (5 percent increase) to an estimated decrease of up to 2.8 µg/L (9 percent decline) in the Lake chlorophyll concentration (Table 6-10) (**Figure 6-4**). After the Lake reaches the target WSE at the end of the filling period, without the proposed treatment wetland, it is estimated that there would be an increase of about 6 µg/L in algal chlorophyll (19 percent increase). With the constructed treatment wetland, it is estimated that there would be a slight decrease in algal chlorophyll of 1.8 to 3.0 µg/L (6 to 10 percent decrease) depending on the wetland design (Table 6-11) (**Figure 6-5**).

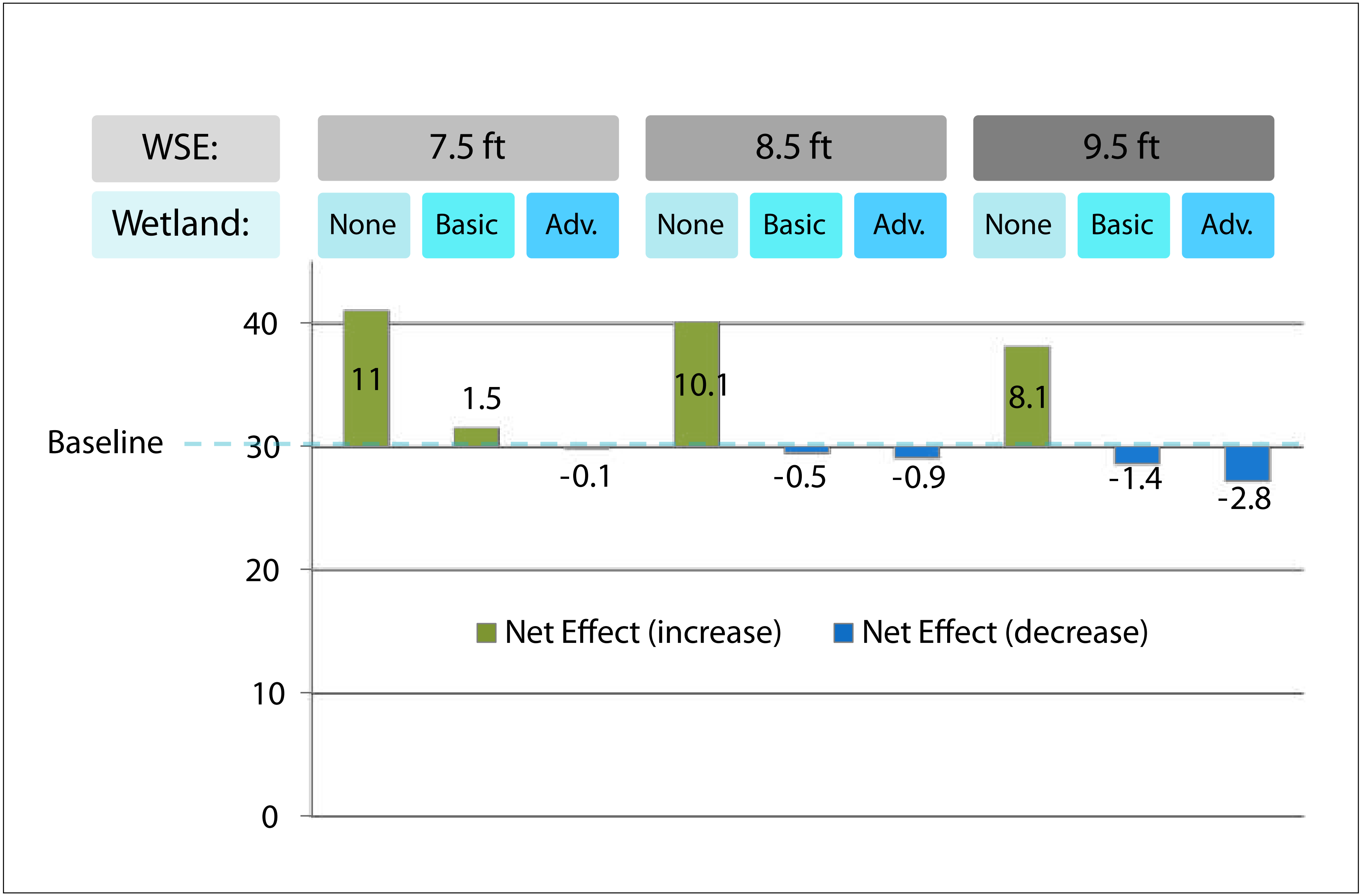
Thus, once the steady state WSE is reached, in conjunction with the treatment wetland, reduced annual average algal concentrations would be expected. Additionally, it is possible that the Lake eutrophication conditions would further improve over time as the reduced annual average algal concentrations result in reduced algal related organic matter loading to the sediments, reduced oxygen depletion in the bottom waters, and reduced internal loading of nutrients.

6.3 Temperature

This section identifies potential effects of increased Lake depths in Lake Merced on temperature in the upper mixed layer of the Lake, to evaluate the potential for impacts on beneficial uses (i.e. Lake fisheries). A simple numerical model was developed to provide the comparison, using existing water quality data in the Lake to verify the model.

6.3.1 Temperature Model Description

The temperature in Lake Merced was modeled using a heat budget approach (Chapra, 1997). The model accounts for each major independent source of energy that enters and leaves the Lake through its boundaries. Most of the energy transfer occurs at the water surface, although transfers also occur at the lake edge and between stratified layers (Fischer et al., 1979). Sources of energy include both shortwave solar radiation and longwave atmospheric radiation, as well as external stream flows or diversions that enter the Lake. Energy sinks include longwave radiation from the lake surface to the atmosphere, evapotranspiration, and both conductive and convective heat losses. Energy transfer between the upper mixed layer and the lower layers provides another sink, but depends strongly on the sharpness of the thermocline, which varies throughout the year and is difficult to accurately model with limited data. Since stratification severely limits the exchange of fluid between vertical layers, this term tends to be relatively small compared with surface heat

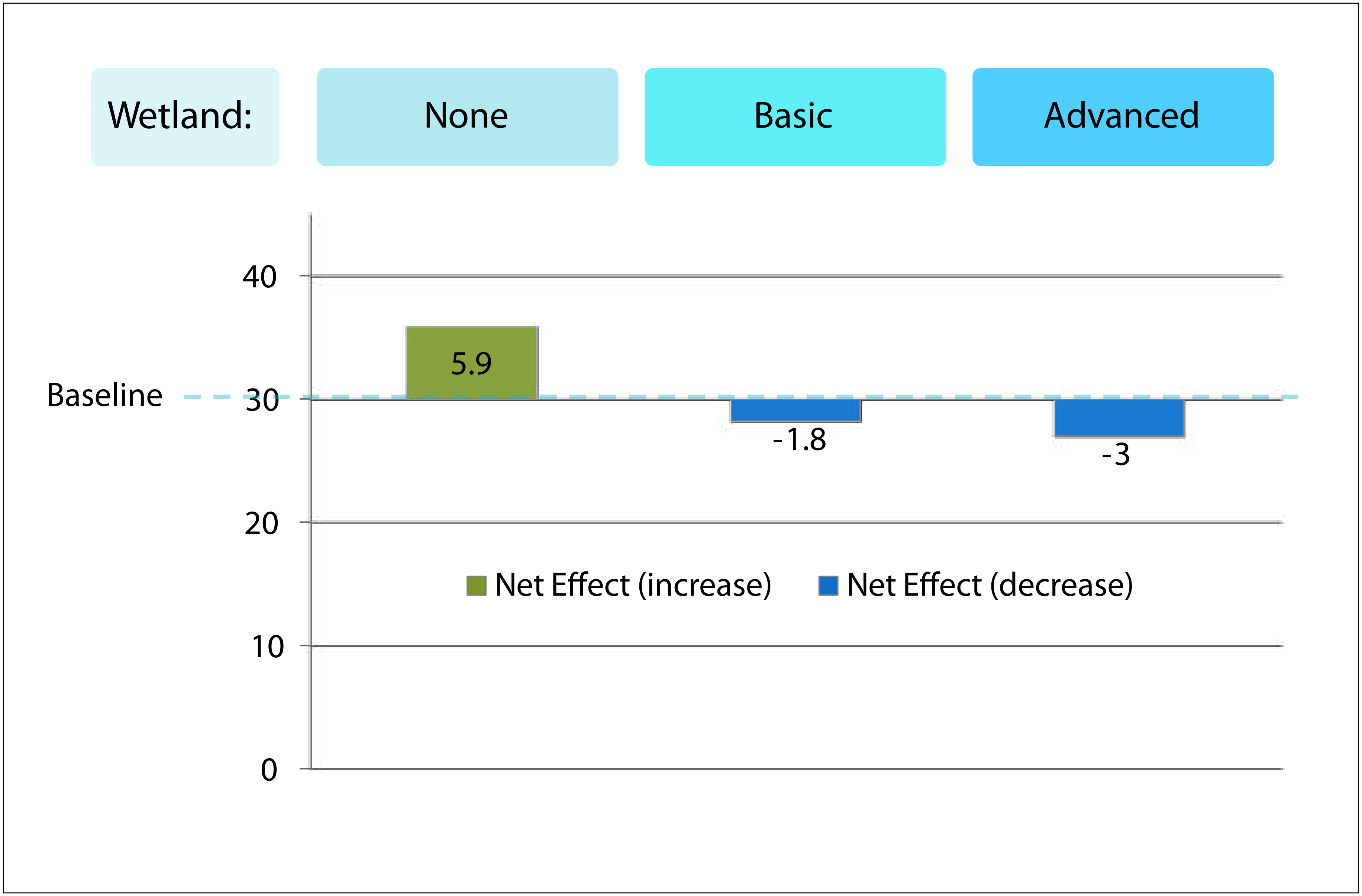


SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 6-4
Filling Period Algae (µg Chl/L)

2-23-0862
Exhibit 6



SOURCE: ESA

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 6-5

Maintenance Period Algae (µg Chl/L)

transfers (Fischer et al., 1979). For this reason, and because of the limited amount of vertical profile data available, this term was not modeled.

Each of the above terms was resolved using the methodology described in Chapra (1997). Local meteorological data was obtained from a weather station at the nearby North San Mateo County Sanitation District WWTP. Atmospheric vertical visibility data collected at Half Moon Bay Airport (NOAA, 2013) were used to determine when clouds and/or fog were present over the Lake. Seasonal net inflows to the Lake, summarized in Section 4.2, were used to estimate the associated heat sources from water entering the Lake.

Heat transfer to the Lake from solar shortwave radiation was resolved directly from solar radiation data from the WWTP. Longwave radiation to and from the Lake is moderated by relative humidity of the atmosphere and the presence of clouds. The former were obtained from the WWTP and the latter from Half Moon Bay Airport (NOAA, 2013). The remaining loss terms are dependent on the Lake temperature (determined at each time step from the model), local wind velocity, and relative humidity. The sky visibility data at Half Moon Bay Airport were used to determine when fog was present, using the methodology of Johnstone and Dawson (2010). Evaporative heat losses were set to zero when fog was present.

The temperature of the Lake was estimated at half-hourly time steps by summing the contributions of each of the above terms using a finite differences method (Chapra, 1997). The model focuses on the upper mixed layer, which is varied in depth based on the observed difference in temperature between sondes near the surface and at lower elevations. Differences in temperature are indicative of thermal stratification, which decreases the depth of the upper mixed layer. The depth was set to 24 ft and 5 ft for well-mixed and stratified periods, respectively. Winds were also allowed to influence the surface layer depth by setting a threshold for overturning (transitioning from stratified to well-mixed conditions). When wind speeds averaged over a 6-hour period exceeded approximately 5 meters per second, the sonde data indicated that the water column was well-mixed. To account for this, the model increases the depth to 24 ft whenever this threshold is achieved.

Assumptions

The model assumes constant meteorological conditions across the lake surface. The net change in energy (heat) in the Lake is assumed to be distributed evenly throughout the epilimnion (i.e. the surface layer is assumed to be well-mixed). When stratification was present, only the upper layer was assumed to be mixed, and lower thermal layers were not included in the analysis. Inflows to the Lake were assumed to have a temperature of 15 °C (59 °F). However, since hourly inflow rates are likely to be small compared to the surface layer volume, this did not have a strong effect on the model results.

Comparison Against 2012 Observations

In order to test the model against a wide range of meteorological conditions, modeling simulated an entire year, from January 1 to December 31, 2012. The Lake was mostly unstratified prior to April 20 and after November 10, 2012. During these periods, the surface temperature measured by ESA was generally less than 14 °C (57 °F) and daily temperature fluctuations in the Lake rarely exceeded 2 °C. In the interim dry season, the Lake was predominantly stratified, with recurrent overturning events briefly returning the water column to well-mixed conditions. As discussed above, these generally corresponded to high-wind events measured by SFPUC. Vertical sonde profiles in October 2012 indicate that the epilimnion was approximately 5 to 7 feet thick, and was separated from the cooler lower layer by a sharp thermocline. Under the dry-season stratified conditions, the surface layer had a mean temperature between 14 and 24 °C (57 and 75.2 °F), and underwent stronger daily temperature fluctuations as high as 3.5 °C. Despite the seasonal and day-to-day variability observed by the sondes, the model generally performed well in both the stratified and well-mixed periods (**Figure 6-6**).

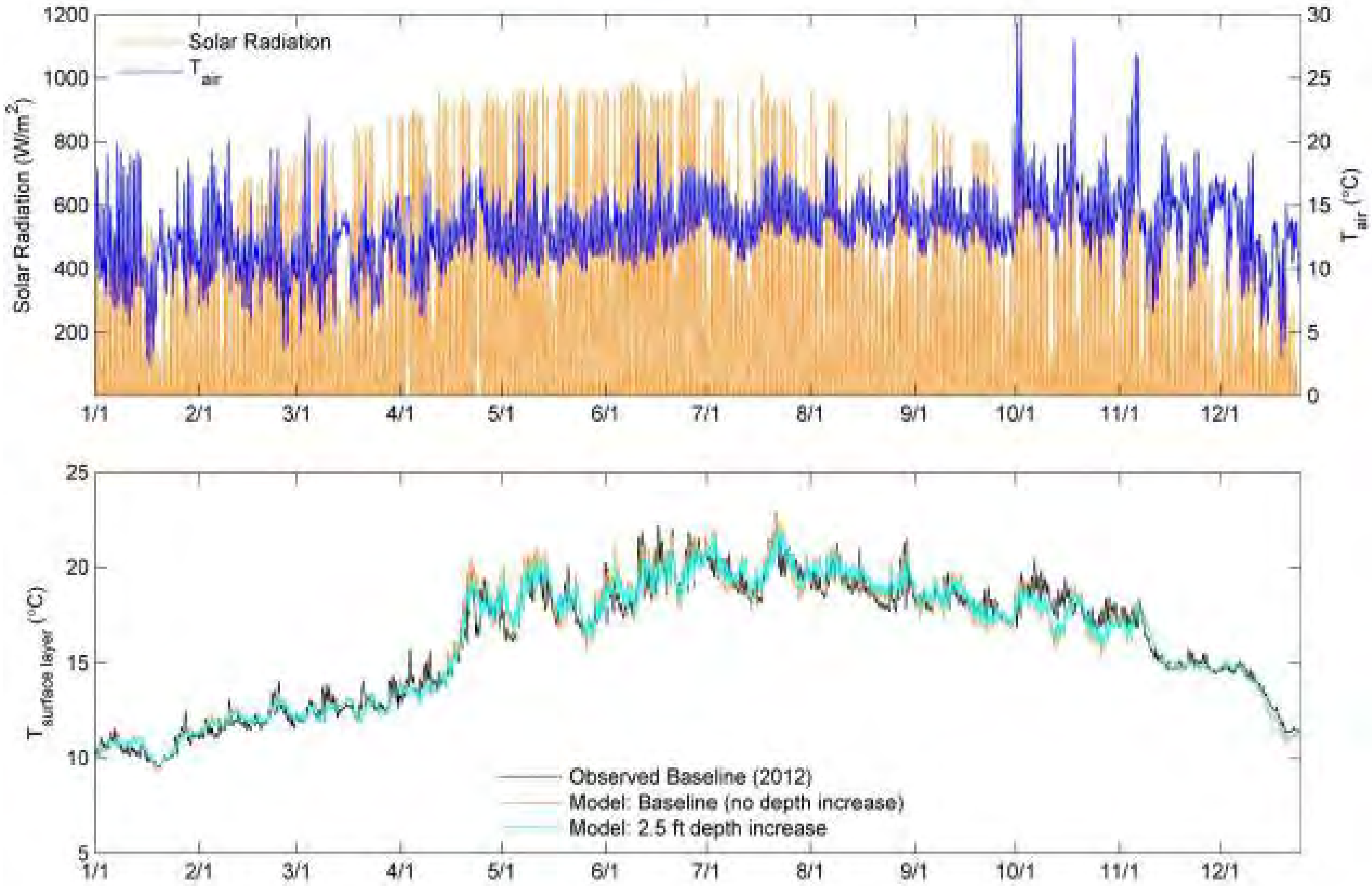
6.3.2 Temperature Model Results of Increased Water Surface Elevations

A half-hourly time series of the Lake surface layer temperature was again simulated for 2012, with surface layer depth augmented under the scenarios described above: relative to the base case, the model increased the elevation of the surface layer by 0.5 ft, 1.5 ft, and 2.5 ft, respectively. The changes in temperature resulting from these scenarios were small. Since the model treated the upper layer as well-mixed, the largest effect of increasing the size of the upper layer was the dampening of daily temperature fluctuations, since the size of the heat sources and sinks relative to the size of the surface layer effectively decreased.

Figure 6-7 compares temperature exceedance curves for each of the above scenarios. The largest difference among scenarios occurred between temperatures of 19 °C and 22 °C (66 °F and 72 °F). As an example, for the base case, surface layer temperatures exceeded 20 °C (68 °F) for roughly 7 percent of 2012 (approximately 600 hours), whereas for an increase in depth of 2.5 feet, surface layer temperatures exceeded this amount by 5 percent (approximately 420 hours). For higher temperatures (21 to 22 °C), the differences became progressively smaller.

This observed dampening effect is shown in more detail in **Figure 6-8**, which tracks the predicted temperature change over a 20-day period in June 2012. For both the baseline case and the case with a 2.5-foot depth increase, the model prediction follows the low-frequency (several-day mean) variability in surface temperature. However, with a 2.5-foot depth increase, the model dampened the daily range of temperature by 0 to 0.7 °C, indicating that the additional depth may allow the upper mixed layer to partially buffer temperature fluctuations.

Although a detailed account of turbulence in the upper water column generated by surface winds was not included in the model, the increased surface layer elevation (increased lake depth) would also likely have the effect of stabilizing the thermocline against wind-mixing events (e.g., Fischer et al., 1979). Mixing in lakes is often associated with periods when the surface layer temperature approaches the temperature of the lower layers. However, mixing also occurs as a result of the oscillating currents generated by wind-waves on the lake surface (see Section 4.4.1). Wind also induces mixing by causing the thermocline to tilt, in some cases causing it to upwell to the water surface and break at the basin edges. Greater surface layer depths impede both of these types of



SOURCE: SFPUC meteorological data, ESA sonde measurements, and ESA temperature model

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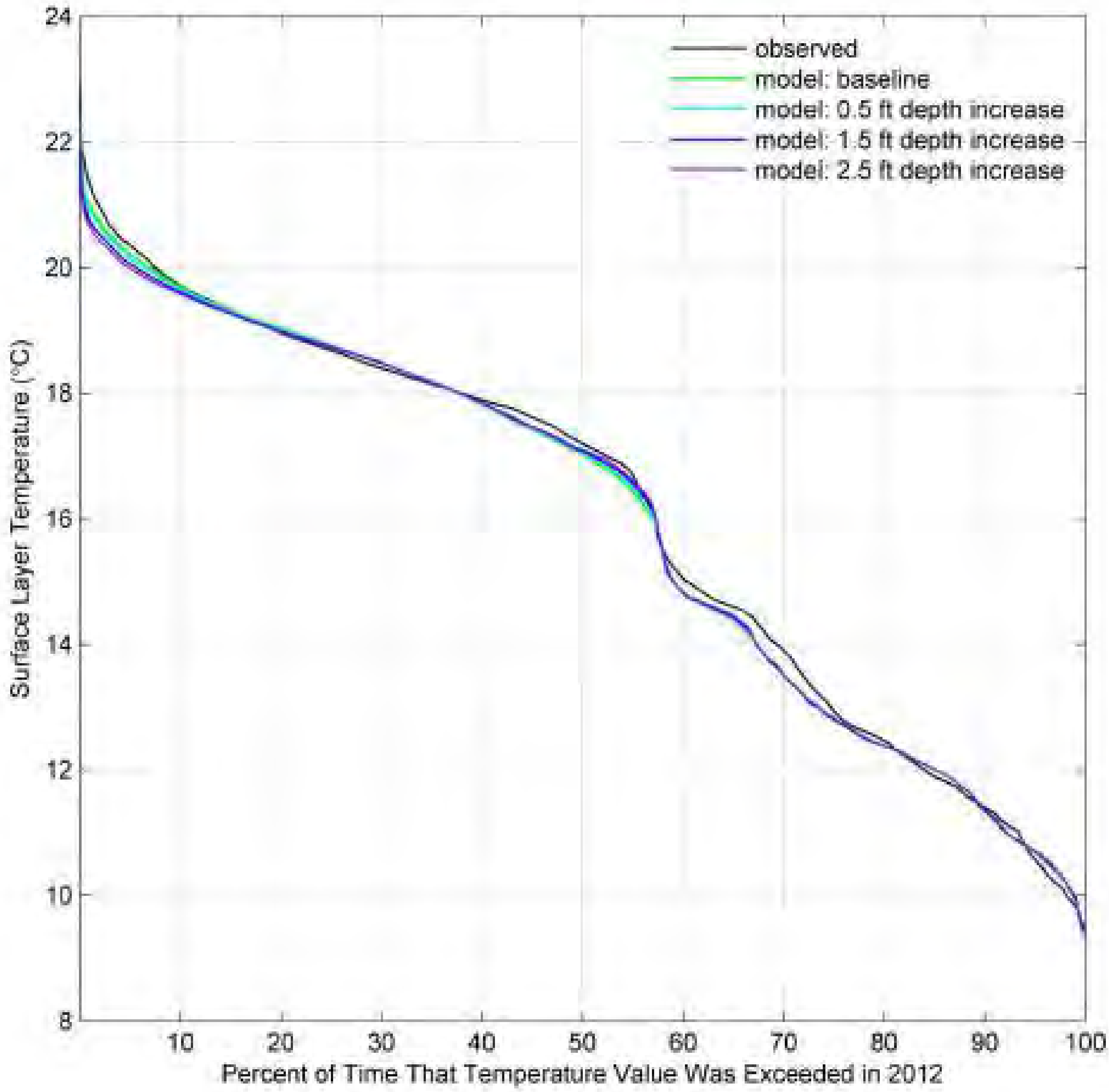
Figure 6-6

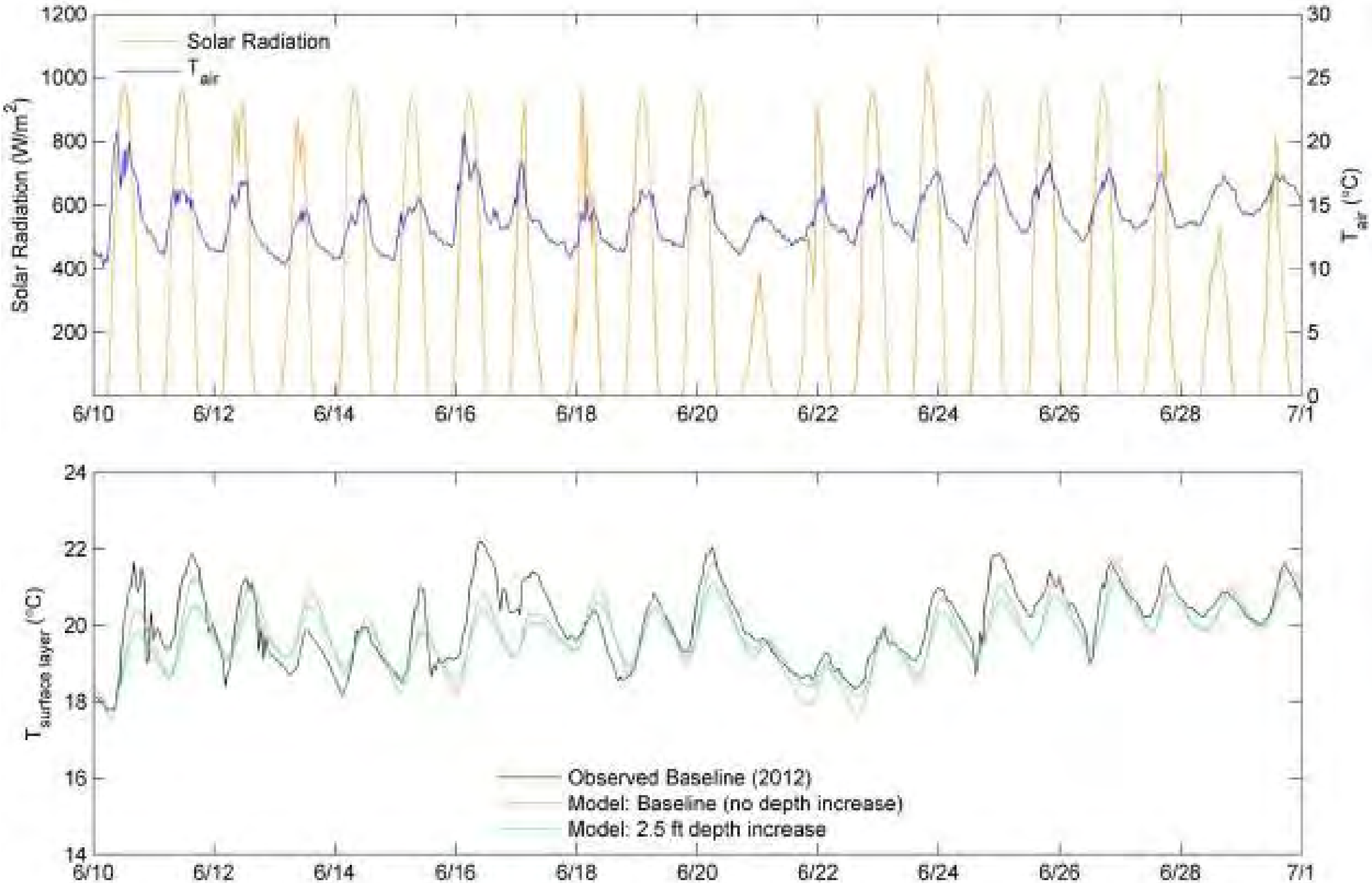
Time series of meteorological forcing, observed Lake Merced surface layer temperature, and model results



SOURCE: ESA sonde data and ESA temperature model

Vista Grande Drainage Basin Improvement Project . D207036.01

Figure 6-7
2012 temperature exceedance curves resulting from observations and modeled conditions in Lake Merced



SOURCE: Daly City WWTP meteorological data, ESA sonde data, and ESA temperature model

Vista Grande Drainage Basin Improvement Project . D207036.01

Figure 6-8

Comparison of meteorological forcing and model scenarios in June 2012 mixing (e.g., Fischer et al., 1979). In 2012, this would have had the effect of prolonging the periods of dry-season thermal stratification.

6.3.3 Temperature Modeling Summary and Conclusions

Greater surface layer depths impede mixing in lakes associated with periods when the surface layer temperature approaches the temperature of the lower layers and as a result of the oscillating currents generated by wind-waves on the lake surface. Against the baseline data collected for 2012, the increased WSE would have the effect of prolonging the periods of dry-season thermal stratification. For each of the WSE increase scenarios modeled (0.5 ft, 1.5 ft, and 2.5 ft), Figure 6-7 compares temperature exceedance curves. With an increase in WSE of 2.5 ft, there would be a reduction in the annual duration of surface layer temperature exceedances of 20 °C (68 °F) and the additional depth may allow the upper mixed layer to partially buffer temperature fluctuations.

6.4 Project Effects on Fisheries

6.4.1 Analysis Methodology

This analysis of potential effects of raising the water surface elevation of Lake Merced on fisheries resources is based on a review of existing information, including a previous assessment of lake water level increases (EDAW, 2004) and a fish community study conducted by Maristics, Inc. (2007), as well as the water quality evaluation presented in Sections 4.2 and 4.3 of this WQA. The results of the assessment of potential changes in the temperature, DO, and pH profiles of the lake were reviewed in light of known habitat requirements of the Lake Merced fish species. Since much of the interest in Lake Merced is in recreational fishing, this analysis focuses on the potential effects to fish species known to be targeted by Lake Merced anglers from raising the water surface elevation of Lake Merced as compared to the existing conditions presented in Sections 4.6.1 and 4.6.2. The assessment of the potential effects to fish species is conducted in part to support subsequent CEQA/NEPA analysis, and as a result, the focus is on a comparison of Project implementation with baseline habitat conditions.

6.4.2 Expected Project Effects on Fisheries

For purposes of this fisheries resource assessment, the results of the water quality assessment presented in Sections 6.1, 6.2, and 6.3 are briefly summarized, and the implications of these results for fisheries resources are discussed below.

Temperature

Baseline temperature ranges documented within Lake Merced are within the tolerance limits for all species present. Temperature tolerance ranges are mainly exceeded for rainbow trout during short-term peak summer periods in surface waters, which are likely behaviorally avoided with fish residing at cooler, lower depths. Based on the results of temperature modeling (Section 6.3) to compare observed temperatures for 2012 water surface elevations to temperatures expected to occur with the potential WSE increases of 0.5 feet, 1.5 feet, and 2.5 feet, only minor changes in the temperature regime of the Lake are expected to occur. The largest difference among scenarios occurred between temperatures of 19 °C and 22 °C (66 °F and 72 °F). As an example, for the baseline case, surface layer temperatures exceeded 20 °C (68 °F) for roughly 7 percent of the time in 2012 (approximately 600 hours), whereas increasing the depth of the Lake by 2.5 feet would likely slightly reduce the frequency of surface layer temperatures exceeding 20 °C (68 °F) to 5 percent of the time (approximately 420 hours). For higher temperatures (21 to 22 °C) however, the differences in modeled temperature exceedance under different depth scenarios became progressively smaller. Moreover, under the 2.5-foot depth increase, the model dampened the daily range of temperature by 0 to 0.7 °C, indicating that the additional depth may allow the upper mixed layer to partially buffer temperature fluctuations.

In summary, the temperature model indicates that increasing the depth of Lake Merced would likely slightly decrease the occurrence of surface water temperatures above 19 °C, and could marginally reduce temperature fluctuations.

Although only surface water temperature effects were modeled, potential water temperature-related effects on fisheries resources would be expected to be minor. A slight reduction in the frequency of surface water temperatures at the upper end of the coldwater species' (e.g., rainbow trout) preference range would be expected to result in a negligible improvement in habitat suitability for these species, while resulting in a negligible reduction in habitat suitability for warmwater species, such as largemouth bass and channel catfish, that are already limited by the prevalence of cool water within the Lake. It should be noted, however, that most fish species avoid surface layers during most of their life cycle.

Water temperatures within mid-level depths frequently occupied by species such as trout and bass would be expected to remain largely unchanged, and the availability (i.e., volume) of these mid-depth temperature conditions would increase, thereby increasing overall habitat availability over existing conditions, particularly for rainbow trout.

Dissolved Oxygen

Lake depth has an effect on DO content by influencing the frequency and duration of stratification. Stratification contributes to low levels of DO in the deeper waters, where algal respiration and decaying organic matter remove oxygen, which is not replenished by mixing with more oxygen-rich water higher in the water column. Historic measurements show that increased depth reduces DO in deep water due to less frequent mixing, so it is expected that operating the Lake under any of the WSE scenarios would result in increases in the frequency and duration of stratification periods and therefore of excursions below the minimum DO objective in the lower portion of the Lake. However, because the WSE would increase, a greater overall Lake volume would be provided that is expected to have DO concentrations above 5 mg/L.

As a result, increasing the Lake levels is expected to result in an overall improvement in aquatic life habitat conditions. While the bottom layer of the Lake would likely continue to experience periodic reduced DO levels that are unsuitable to rainbow trout and outside the optimal range for more tolerant species such as carp and channel catfish, the volume of water with suitable DO concentrations above the low-DO bottom layer would increase over existing conditions, thereby effectively increasing the total amount of habitat containing suitable DO levels.

pH

As noted above, Lake Merced has relatively high alkalinity with an estimated equilibrium pH of about 8.5. Under current conditions, the pH level frequently peaks above 8.5 during sunny afternoons as a result of algal photosynthesis. Under the proposed project, once the steady state is achieved, there would be a slight decrease of 6 to 10 percent in algal concentrations. However, it is expected that upper mixed layer (epilimnion) pH would continue to exceed of 8.5. The lower mixed layer (hypolimnion) pH is expected to remain relatively unchanged, with values below 8.5. Thus, pH conditions for fisheries resources would remain within the upper portion of the tolerance range of freshwater fish. However, the relatively high equilibrium pH levels to which resident fish are acclimatized in Lake Merced, as well as the relatively gradual nature of periodic pH increases, are expected to maintain the diverse fish assemblage of Lake Merced.

6.4.3 Conclusions

The fishery-related ecosystem of Lake Merced can be summarized as a moderately enriched Lake that supports self-sustaining populations of native and non-native fish species (Maristics, 2007). Temperature, DO, and pH profiles are not expected to change significantly with increased WSEs. Although periods of weak stratification may last slightly longer (on the order of a few days at most), the range of temperature, DO, and pH conditions is not expected to change significantly. Therefore, no significant changes to habitat suitability for warmwater or coldwater fish are anticipated as a result of raising WSEs. Overall, increased WSEs would increase the total available habitat with suitable temperature and DO levels for the cold and warmwater fish species present.

6.5 Project Effects of In-lake Treatments

In addition to the water quality improvement resulting from lake level increases and use of the stormwater treatment wetland, the project includes intake and recirculation of lake water during dry weather periods to maintain the treatment wetlands. The intake of lake water would be directed to areas of concentrated surface algae, allowing for direct removal of algae and associated substantial decreases in chlorophyll. The project also includes controlled overflows of lake water to the Vista Grande Tunnel, using a siphon to allow higher TDS and higher salinity bottom water to be displaced, increasing the benefit of flushing water out of the lake. These project components and their effects are further described below.

6.5.1 Recirculation of Lake Water for Treatment Wetland Maintenance and Algae Control

During periods of very low or no flow, a recirculating pump would draw water from Lake Merced to maintain the treatment wetlands. Summer maintenance flows would be adaptively managed to filter algae skimmed directly from the lake surface and pumped to the wetlands. The skimmer would have a floating structure with some wind protection that draws water from the upper few inches of the lake surface. If the maintenance inflow were withdrawn only from Impound Lake, there would not be a high enough concentration of algae treated to beneficially influence lake water quality. Thus, the Project proposes to install a piped connection (flexible hose) from the natural algae concentration site(s) within South Lake into the constructed treatment wetlands.

The use of treatment wetlands for algae control is becoming of greater interest given recent concerns such as toxic algae blooms. The method depends on the natural ability of properly constructed wetlands to filter out particles. The largest example is the 760-acre wetland at Lake Apopka in Florida, called the Lake Apopka March Flow-Way. The wetland was created by the St. Johns River Water Management District to remove particles including phosphorus to meet standards downstream of the outflow. The water quality in Lake Apopka has been degraded in part by lowering the lake level and farming the drained areas. Agriculture combined with the loss of submerged aquatic plants has substantially increased the particles in the lake water and increased suspended matter. The Lake Apopka wetland was operated with a hydraulic retention time (HRT) between 2 and 7 days at a water depth of 1 to 2 feet but with a re-cycled pumped flow. It removed 92 percent of TSS over 7 years (Dunne et al., 2011; St. Johns River Water Management District, 2013). An algae-filtering wetland also has recently been proposed for Lake Hodges, a 1,200-acre reservoir in San Diego. Almost all properly designed wetlands for which there are data show good removal of particles.

The kinds of blue-green algae that form surface scums on Lake Merced are naturally buoyant due to their small air bladders (gas vesicles). The large size of the colonies increases the vertical speed of rising for these algae so that they easily form scums during a calm night. This natural concentration of blue-green algae can result in concentrations at the surface scums of over 1,000 times background epilimnion levels. An algae removal system can take advantage of this natural vertical concentration and the fact that surface concentration occurs when light winds blow the buoyant surface scums into coves or along the shore. However, buoyancy varies with the time of day and the health of the algae, so not all the algae will be highly buoyant at any one time. Similarly, not all algae will accumulate at the same site. Therefore, at Lake Merced, reduction of nuisance blue-green algae in lake surface waters would be most effective if skimming is targeted in areas where natural concentration factors of over 1,000 times background epilimnion levels occur, such as in coves or along the shore (Appendix E).

The Visa Grande treatment wetland would have a unit process design that consists of several cells with dense stands of cattails in some cells and bulrush in others. There would be no open water cells, and hydraulic short-circuiting would be prevented by a flat, sloped bed and dense reeds. This design was intended to maximize removal of soluble nutrients like nitrogen and iron, and would be suitable for the removal of algae particles with no further modifications.

The treatment wetland would likely be designed such that the summer minimum flow of 0.1 cfs (0.2 acre-feet/day) would be sufficient to ensure that the wetland plants are maintained.

Calculations developed for determining the feasibility of utilizing the wetlands as a sustainable filter for removal of blue-green algae from the lake surface determined that a 2-day hydraulic residence time would be needed. The proposed constructed treatment wetlands would be sized such that they could accommodate a maximum flow rate of 1.4 cfs, to achieve this 2-day hydraulic residence time. A skimmer would be used to facilitate the uptake of lake water with the highest concentrations of algae. The direct removal of concentrated surface algae by skimming would effectively achieve substantial decreases in chlorophyll, to the extent that concentrated, localized surface scums exist in the lake. It would also have the benefit of being visually obvious to the public.

6.5.2 Controlled Overflow of Lake to Tunnel

The project would replace a portion of the existing Lake Merced overflow with an adjustable-height weir that would be used to control the lake level and allow water from Lake Merced to be diverted back into the Vista Grande Canal just upstream of the tunnel to flow to the Ocean Outlet. Once Lake Merced reaches the target WSE (approximately 3.5 years following project implementation), continued operation would result in water levels exceeding the target WSE with overflows at the weir being diverted back to the Canal. Further, the project would include flexible piping (siphon) that would allow lake water from the hypolimnion to be diverted via the weir back to the Canal to improve lake water quality by flushing higher alkalinity water from near the lake bottom.

Overfilling and thereby flushing the Lake with low-alkalinity stormwater could reduce its background pH by diluting salts and displacing higher alkalinity water. The elevated pH level in Lake Merced is likely due to the historical accumulation of alkaline minerals since it has been a terminal lake for decades (i.e., no outflow to other water bodies), as discussed in Chapter 4, Lake Merced Existing Conditions. Historically, basin runoff flowed to Lake Merced from a much larger natural watershed and Lake Merced was hydrologically connected to the ocean, resulting in accumulated salts to be flushed out to the Pacific Ocean. Use of a siphon would partially restore some of the natural hydrology to Lake Merced that occurred under historic conditions.

During winter months, heavier, higher TDS and higher alkalinity water would tend to be in the bottom layer when lighter, low-salinity stormwater flows would be conveyed to the lake and tend to reside in the top layer (Appendix E). Therefore, using a siphon would allow the higher TDS and higher salinity bottom water to be displaced, increasing the benefit of flushing water out of the lake. During the winter wet season when Lake levels are high enough that this option would be most effectively implemented, the Lake tends to be more fully mixed as a result of wind action on surface waters, so there may be reduced benefits from diverting bottom waters during the winter as compared to periods of extended stratification in the summer. However, lakes that have been mixed as a result of wind action and are characterized by isothermal conditions are often chemically stratified because the wind-induced heat transfer rate may not be sufficient to provide sufficient energy to disrupt density layers induced by dissolved chemicals. Therefore, there would likely be a water quality benefit to operation of a siphon under various mixing regimes since bottom water generally contains more nutrients, sunken zooplankton fecal pellets, amorphous particulate matter, as well as more saline water. Operation of the siphon to release 10 percent of the lake volume per year (200 af) would likely result in a lower baseline pH, representing a water quality improvement, within approximately 10 years. Operation of the siphon, such as the timing, frequency, and duration of diversions of lake water from the hypolimnion to the Canal, would be implemented as part of the adaptive management framework of the project through the LMP. An operational goal would be to operate the siphon to flush out the highest alkalinity water to the maximum extent practicable based on available water supply, without compromising maintenance of target water surface elevations.

6.5.3 Summary of In-lake Treatment Measures

Operation of the in-lake management actions proposed as part of the Project would generally further improve water quality within Lake Merced as compared to operation of the project without such active in-lake treatment measures through the removal of algae and the flushing of the Lake with low-alkalinity stormwater to reduce the elevated background pH by diluting salts and displacing higher alkalinity water.

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CHAPTER 7
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CHAPTER 8
List of Preparers

8.1 Report Preparers

Environmental Science Associates (ESA) – San Francisco, CA. ESA developed and executed wet and dry season monitoring plans to characterize baseline conditions in Lake Merced and the Vista Grande Canal after review of available existing water quality data and reports relevant to the proposed project to identify data gaps. Using existing data and data collected during the 2011-2012 wet and dry seasons, ESA evaluated the existing conditions in the Lake and Canal and prepared a preliminary analysis of potential effects of the proposed project on water quality in Lake Merced with assistance from EOA and Alex Horne Associates. As part of this effort, ESA prepared the temperature model used to preliminarily evaluate potential fisheries effects. ESA is the primary author of this report.

Jacobs Associates – San Francisco, CA. Jacobs Associates provided the description of the proposed project operation and review of the water quality analysis.

EOA, Inc. – Oakland, CA. EOA assisted ESA in the development of water quality monitoring plans described above, review and interpretation of water quality data, and assessment of potential health risks associated with bacteria indicators and pathogens. EOA provided technical review of this report.

Alex Horne Associates (AHA) – El Cerrito, CA. Dr. Horne supplies supporting expertise on the preliminary analysis of potential effects of stormwater diversions on Lake Merced's ecology including effects of increasing the water elevation. As part of his contribution to the water quality analysis, Dr. Horne created a simple mixing model for Lake Merced to assess the relative effects of different water depths on eutrophication.

City of Daly City, CA. The City of Daly City Department of Water and Wastewater Resources provided review of the water quality monitoring plans and findings that informed this report, as well as review of the description of Vista Grande Canal baseline and potential post-project operating conditions.

Downey Brand – San Francisco, CA. Downey Brand reviewed this report for its interpretation of water quality regulatory context.

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APPENDIX A
System Understanding and Approach

Contents:

2012 Draft System Understanding and Assessment Strategy – South Lake Merced Alternative

Vista Grande Drainage Basin Improvement Project – Water Quality Data Objective Matrix

Concurrence with Proposed Regulatory Process for Vista Grande Drainage Basin Improvement Project, Lake Merced Alternative, San Francisco Bay Regional Water Quality Control Board

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DRAFT SYSTEM UNDERSTANDING AND ASSESSMENT STRATEGY

South Lake Merced Alternative

Introduction

The purpose of this document is to provide an understanding of current water quality conditions in South Lake Merced, the processes and factors governing water quality in South Lake Merced, how the contribution of Vista Grande Stormwater to South Lake Merced might alter existing water quality conditions in South Lake Merced, and the actions to be taken to assess the potential for alterations to existing water quality conditions. This document also reviews regulatory considerations required in undertaking the assessment.

South Lake Merced Alternative Description

The City of Daly City (City) is currently considering several conveyance and storage alternatives to address stormwater overflows that exceed the existing storm drainage capacity of the Vista Grande Canal and Tunnel and result in local flooding. One of the alternatives under consideration involves conveying dry weather and stormwater flows from the Vista Grande Canal into South Lake Merced. The City and County of San Francisco (CCSF), as well as several local nongovernmental groups, have expressed an interest in managing Lake Merced levels between a preliminary target level of 5.0 to 9.5 feet San Francisco City Datum (target levels are not yet finalized), with some fluctuation due to rainfall patterns. The proposed South Lake Merced Alternative would satisfy several objectives by allowing the CCSF to operate Lake Merced within desired water levels, helping to reduce local flooding and restoring Lake Merced's historic drainage conditions (Jacobs Associates, 2011).

The Vista Grande portion of the City's stormwater collection system drains the northwestern area of Daly City and unincorporated portions of San Mateo County. The underground collection system conveys the storm flows to the Vista Grande Canal and then into the Vista Grande Tunnel, which discharges through the Daly City outfall structure into the Pacific Ocean at the beach below Fort Funston. The trapezoidal Vista Grande Canal, adjacent to the west side of John Muir Drive, has a capacity of 500 cubic feet per second (cfs) and lies parallel to the southwest shores of Lake Merced. At the terminus of the Canal is the mouth of the 3,000-foot long Vista Grande Tunnel, which has a capacity of 170 cfs. In wet weather, stormwater drains into the Vista Grande Canal, through the Tunnel, and into the Daly City outfall structure. Historically, wet weather flows in excess of the capacity of the Canal and the Tunnel have occasionally resulted in local flooding and overflows across John Muir Drive into South Lake Merced, causing property damage, bank erosion, traffic nuisances, and public safety issues (RMC, 2006).

The proposed project would reroute a portion of the dry weather and wet weather flows from the Vista Grande Canal into Lake Merced dependent upon flow and antecedent conditions In all options, water would be screened using a debris screening system to trap all material > 5 mm in diameter. During dry weather and low wet weather flow events, authorized non-stormwater and stormwater would be screened for trash and debris and then routed through a constructed wetlands natural treatment system before entering South Lake Merced. Specified winter flows that exceed the capacity of the wetlands natural treatment system would also be routed to South Lake Merced. The remainder of storm water flows would continue to be routed to the Pacific Ocean via the Vista Grande Canal and Tunnel (Jacobs Associates, 2011).

The proposed project would include construction of new facilities including a collection box, a gross solids removal device, a 1,400 foot long box culvert to replace part of the existing Vista Grande Canal, a semi-automated hydraulic diversion structure, a 700 foot long box culvert under John Muir Drive, a screen discharge structure in Impound Lake, a wetlands natural treatment system and a screened low-level intake/overflow structure at South Lake (Jacobs Associates, 2011).

Lake Merced System Description

Background

Lake Merced is the largest freshwater lake located within the City and County of San Francisco (CCSF) and is operated and maintained by the San Francisco Public Utilities Commission (SFPUC). Lake Merced is located in the southwestern corner of San Francisco, bounded by Skyline Boulevard, Lake Merced Boulevard and John Muir Boulevard, approximately 0.25 miles east of the Pacific Ocean. The lake was originally a coastal lagoon that was intermittently connected to the ocean via a channel that ran through the current location of the San Francisco Zoo. This connection was permanently closed in 1895 with the construction of Skyline Boulevard and the Great Highway (SFPUC, 2011). Lake Merced is currently used as a recreational resource and non-potable emergency water supply source for the City of San Francisco.

Watershed and Land Use

Urban development has significantly reduced Lake Merced's original estimated watershed size of 6,320 acres to its current size of approximately 650 acres. The lake itself makes up slightly less than 40 percent of this area. The rest of the watershed, approximately 369 acres, is composed of upland areas. Harding Park and Jack Fleming Golf Course account for about 183 acres of the upland watershed, roads and neighborhoods account for 31 acres, and the remainder (155 acres) is primarily undeveloped open space located between the lake and the surrounding roadways. Aside from the golf course, upland areas primarily consist of undeveloped open space vegetated with wetland and upland species including coastal and willow scrub, grassland, herbaceous and bulrush marsh communities (SFPUC, 2011).

Climate and Precipitation

The climate in the Lake Merced area is generally mild, with an annual average temperature of 55.5 ºF. January is generally the coolest month with an average temperature of 50.9 ºF, while September is the warmest month with average temperature of 59.9 ºF. Average annual precipitation is 19.98 inches, with a majority of the rain occurring in the winter months. Seasonal average temperature and precipitation data for the period 1948 – 2010 are presented in **Table 1**.

TABLE 1
AVERAGE REGIONAL TEMPERATURE AND PRECIPITATION

Season	Average Temperature (ºF)	Average Precipitation (inches)
Annual	55.5	19.98
Winter (Dec – Feb)	51.6	11.38
Spring (Mar – May)	54.1	4.45
Summer (Jun – Aug)	58.1	0.25
Fall (Sept – Nov)	58.0	3.90

SOURCE: National Weather Service Climate Summary for San Francisco Richmond (Station 047767) for years 1948-2010.

Hydrology

Lake Merced lies in the San Francisco Coast Watershed and the Westside Groundwater Basin, and is comprised of four lakes: North, East, South, and Impound lakes. North and South Lakes are hydrologically connected via a culvert and North and East Lakes are connected via a narrow channel under a pedestrian bridge. Impound lake was formed with the construction of a sewer line across the southern tip of South Lake which restricted the hydrologic connection. The total combined surface area of all four lakes has historically ranged from 245 to 273 acres, depending on water level, and total volume of the lakes is approximately 1 billion gallons. South Lake, with a surface area of approximately 175 acres, is the largest of the four lakes and contains more than 66 percent of the total volume of the lakes (SFPUC, 2011). Water depth varies between the lakes, as shown in **Table 2**:

TABLE 2
LAKE DEPTH

Lake	Depth Range (feet)	Average Depth (feet)
Impound	2 – 10	5.5 – 6
North and East	3 – 20	10 – 11
South	3 – 21	13 – 15

SOURCE: SFPUC, 2011

The main sources of inflow to the lake are precipitation, stormwater runoff and manmade additions (**Table 3**). The only physical outlet from Lake Merced is from South Lake via a 30-inch diameter overflow at elevation 12.5 feet that connects to the Vista Grande Tunnel immediately

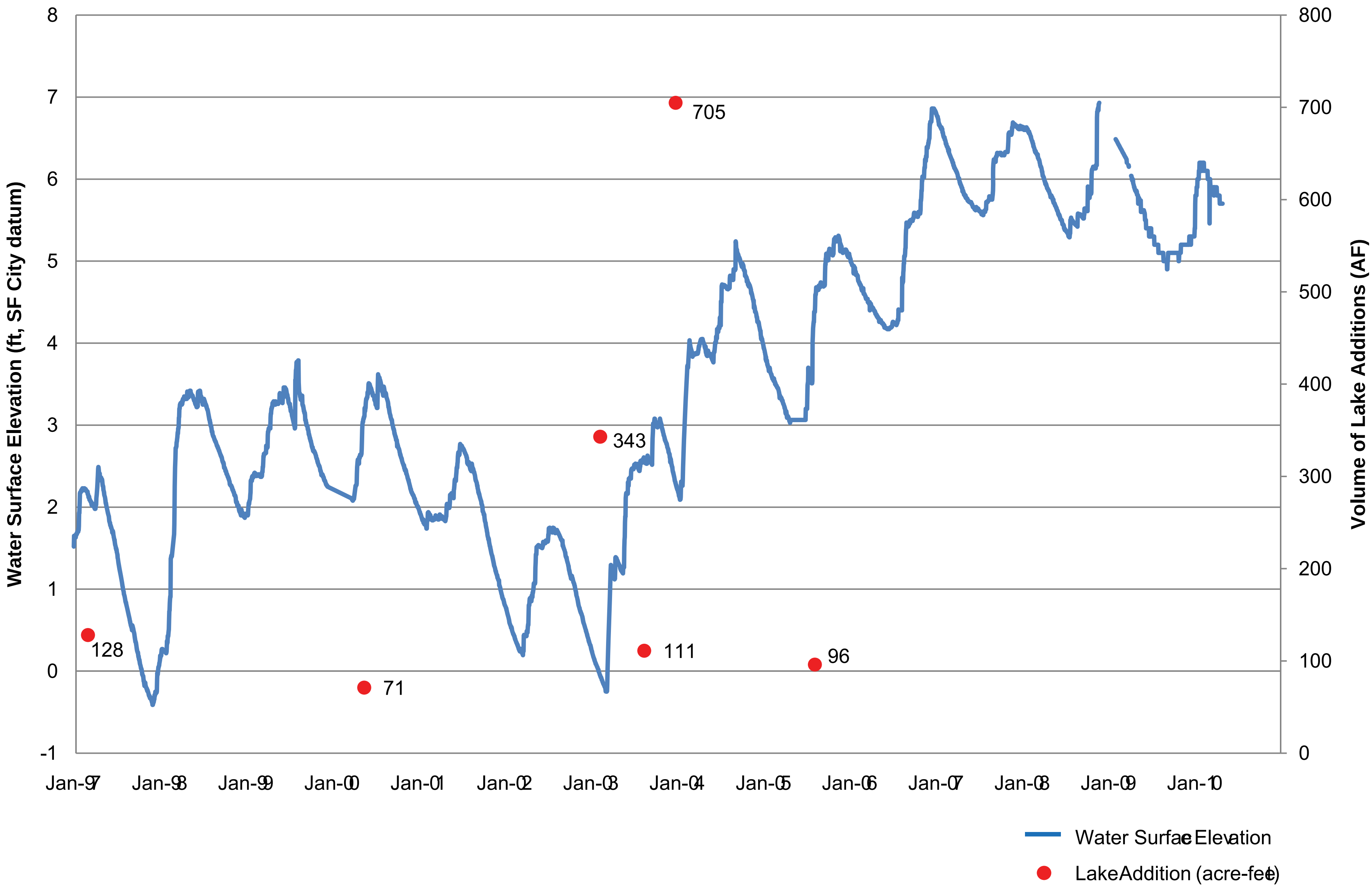
TABLE 3
LAKE MERCED SOURCES OF INFLOW AND OUTFLOW

Water Source/Sink	Percent of Total
Inflow	
Precipitation	55
Stormwater	25
Manmade additions	19
Groundwater	1
Outflow	
Evaporation	67
Transpiration	14
Groundwater infiltration	14
Manmade extractions	5

SOURCE: SFPUC, 2011

downstream of the tunnel connection to the Vista Grande Canal. Currently, the largest source of outflow is evaporation, followed by transpiration, groundwater infiltration and manmade extractions. Stormwater from within the Lake Merced watershed is either collected into the San Francisco's combined sewer system or is discharged into Lake Merced via storm drains, sheetflow from surrounding uplands or overflow from the adjacent Vista Grande Canal (during large storm events). Both Daly City and CCSF are considering options to return stormwater flows in the watershed to Lake Merced. In addition to Daly City's proposed South Lake Merced Alternative of the Vista Grande project (described below), CCSF is evaluating longer term planning initiatives that would retain stormwater runoff within the watershed by incorporating low impact development (LID) techniques and separation of stormwater within future redevelopment plans in the watershed.

Water levels in Lake Merced fluctuate seasonally and across different time periods. Historical data show a trend of a decline in lake levels from approximately 13 feet City Datum in the mid 1930's to a low of -3.2 feet City Datum in 1993 (SFPUC, 2011; Kennedy/Jenks, 2009). After 1993, lake levels began to rise due to increases in rainfall and water additions by SFPUC. South Lake Merced water surface elevations from 1997-2009 and the dates and volumes of SFPUC water added are shown in **Figure 1**. There was a limited addition of treated stormwater to South Lake Merced from 2003 to 2009 as part of the Lake Merced Pilot Stormwater Enhancement Project (EOA 2011). The volumes ranged from approximately 100,000 gallons up to 5.4 million gallons per event. As of June 2011, the lake level was at 6.9 feet City Datum.



SOURCE: Kennedy/Jenks, 2010

System Understanding and Assessment Strategy - South Lake Merced Alternative

Figure 1

South Lake Water Surface Elevations 1997-2009

Historic and Existing Water Quality

Monitoring of Lake Merced water quality began in 1997 by the San Francisco Public Utilities Commissions (SFPUC) Environmental Services section of the Water Quality Bureau. More recently, the Limnology section of the Natural Resources Bureau has continued this monitoring on a quarterly basis. The monitoring program is similar to monitoring programs at SFPUC drinking source water reservoirs and is conducted by the same department at SFPUC. Sampling occurs between 3 and 8 times per year, but is typically conducted quarterly (KJ, 2010). Samples are taken at 4 locations: North Lake, East Lake, South Lake near the Pump Station, and South Lake near the police Pistol Range. Of the two South Lake locations, the Pump Station location is closest to the proposed location for Vista Grande Canal stormwater to be conveyed into South Lake.

For the majority of parameters, samples at each location were taken at various depths, often starting at the surface and decreasing at 5-foot intervals until a 15-foot depth with intermittent samples collected near the bottom of the Lake. In January 2010, Kennedy/Jenks Consultants finalized the Lake Merced Water Quality Data Organization, Review and Analysis (KJ, 2010). Based on the review of water quality data gathered from 1997 to 2008 it was determined that the "health" of Lake Merced, based on selected indicator parameters, remained relatively constant from 1997 to 2008 and that there was a slight improvement in Lake clarity (Secchi depth). Also, during the 1997-2008 period, there were no significant changes in algal biomass levels, with the exception of periodic increases in concentration due to algae blooms (KJ, 2010).

SFPUC updated the KJ data analysis to include 2009 lake monitoring results and calculated various summary statistics (median, minimum, maximum, standard deviation, and coefficient of variance) to evaluate the extent of change between 1997-2009 (SFPUC, 2010). **Table 4** provides a data summary for key nutrient and algal related parameters.

Appendix A contains a more detailed graphical summary of results over this 1997-2009 time period from the South Lake (Pump Station) SFPUC monitoring location, including temperature, dissolved oxygen, pH, ammonia, nitrate, and total phosphorus. Box and whisker plots of the data are presented with the results grouped by season (Winter = Jan-Mar, Spring = Apr-Jun, Summer = Jul-Sep, Fall = Oct-Dec) and grouped results presented by depth sampled (surface, 5-feet, 10-feet, 15-feet, and all depths together). The bar within each box represents the median value (half of the measurements are greater than this value and half less than this value), the upper side of the box represents the value of the upper 75th percentile of the data, the lower side of the box represents the value of the lower 25th percentile of the data, the end of the upper whisker represents the value of the upper 95th percentile of the data, and the end of the lower whisker represents the value of the lower 5th percentile of the data.

TABLE 4
DATA SUMMARY OF KEY NUTRIENT AND ALGAL RELATED PARAMETERS
(South Lake Pump Station)

Parameter	Units	Averages			1997-2009					Number of Sampling Dates
		1997-2008	1997-2009	Change	Median	Min.	Max.	Standard Deviation	Coefficient of Variance	
Ammonium (NH4+)	mg/L	0.06	0.05	0	0.04	ND	0.65	0.07	1.22	57
Nitrate (NO3-)	mg/L	0.03	0.03	0	ND	ND	0.62	0.09	2.80	59
Orthophosphate	mg/L	0.06	0.06	0	0.05	ND	0.23	0.05	0.86	59
Total Kjeldahl nitrogen (TKN)[1]	mg/L	3.76	3.67	-0.09	2.38	ND	28.2	3.67	1.00	55
Total Phosphorus	mg/L	0.14	0.15	0.004	0.15	ND	0.40	0.06	0.41	58
Chlorophyll	ug/L	27	26	-0.4	23	5	100	15	0.58	53
Secchi depth	Feet	1.8	1.8	0	1.8	1.0	3.0	0.5	0.27	59

NOTE:
[1] Samples were not collected on 3/24/09

SOURCE: SFPUC, 2010

Processes Affecting Lake Water Quality

There are numerous processes and variables within a lake that can affect water quality. Stratification and nutrient enrichment are two main processes that have the potential to influence levels of dissolved oxygen and pH within a lake system. The following section outlines both of these processes and provides a brief assessment of the current and historical trends and available data for Lake Merced with respect to each process.

Thermal and Chemical Stratification

Thermal stratification is the separation of water layers within a lake system, wherein warm, less dense surface waters (epilimnion) float over deeper, cooler, denser waters (hypolimnion). Chemical stratification, shown by gradients of chemicals like oxygen and nutrients, often results after thermal stratification. Thermal stratification develops as surface water temperatures rise in lakes during spring and a vertical temperature gradient or thermocline develops. Bottom waters are then separated from the surface waters, due to the differences in water temperature and thus density. Depending on lake morphology and environmental conditions, a lake may undergo periods of temporary weak stratification or may experience strong seasonal stratification that lasts from spring to late fall. Interpretations of historic data have generally suggested that Lake Merced tends to undergo weak intermittent thermal stratification (EDAW, 2004).

Thermal stratification has important water quality implications because of its influence on dissolved oxygen levels, nutrient dynamics and habitat quality for fish and other aquatic organisms within the lake. In eutrophic lakes with large algal populations, stratification can have significant effects on pH and DO levels in the separated surface and bottom waters. As indicated by Secchi disk readings, sufficient sunlight for algal growth only penetrates about five feet (approximately 2.5 times Secchi depth) in South Lake Merced. Algal photosynthesis is therefore primarily limited to this shallow photic. In a water column that is mixing, algae growth is limited by the amount of sunlight available to phytoplankton cells. The availability of sunlight (irradiance) is a function of the ratio between the euphotic depth (z_{eu}) and the depth of mixing (z_{mix}). If z_{eu} equals z_{mix} (ie. $z_{eu}/z_{mix} = 1$) then the cells are constantly illuminated and photosynthesis is continuous during and maximized during the daylight period. In Lake Merced, the photic zone is a fraction of the mixed, epilimnion zone with a z_{eu}/z_{mix} ratio of about 1:2. In terms of water quality, this ratio indicates that the algae present in the lake are most limited by access to light and not nutrients since half of them spend the daylight hours mixed down into the gloomy deeper water.

During photosynthesis, algae take in carbon dioxide from the water to produce organic (carbon based) matter, and in the process produce and release oxygen. During intense photosynthesis the imbalance between instantaneous uptake of carbon dioxide and its resupply from the air or the dissolved carbonate pool causes the pH to rise. There are sufficient algae in Lake Merced (chlorophyll a ~ 26 ug/L) to produce intense photosynthesis in surface waters. This is why the surface waters in the lake show both elevated pH and DO levels compared to deeper water. The effect is most pronounced on calm, sunny days when the upper few feet of the lake become unusually warm and stable. Under more normal conditions, afternoon winds stir the upper waters, resulting in elevated pH through much of the epilimnion.

Conversely, in the cooler denser bottom waters (hypolimnion), separated from the warmer less dense and mixed surface waters, pH and DO levels are lower. No photosynthesis occurs below the photic zone; therefore, there is no photosynthetically increased pH. The waters below 10-15 feet remain partially or totally isolated from the surface and the potential for reaeration via diffusion and wind mixing. Algal respiration will deplete the available oxygen and produce carbon dioxide, reducing pH in deep waters. Possibly more important relative to contributing to low DO conditions, is the oxygen demand from the decay of organic matter in the bottom sediments. These factors can combine to reduce bottom DO levels to near zero for periods of time until the stratification breaks down and the lake mixes again. This appears to be the situation at Lake Merced in late summer and fall based on preliminary data from the continuous recording probes in 2011.

The following variables may influence the degree and extent of stratification in Lake Merced:

Temperature/Season

Lake Merced has an atypical temperature regime for its latitude. During warm periods from the spring through the fall, rising air temperature and solar radiation initiates stratification by warming the surface layers of a lake. In many U.S. lakes away from cool ocean water, stratification occurs easily since summer air temperatures typically reach 80-90°F. In general, San Francisco is characterized by much cooler air temperatures, ranging from 51.6 °F in the winter to 58.1 °F in the summer. In addition, the coastal marine layer tends to persist throughout much of the day, reducing incoming solar radiation. These cool weather patterns tend to minimize the warming of Lake Merced. Average yearly surface temperatures are approximately 61 ºF (SFPUC, 2009). However, during periods of warmer weather, which tend to occur in the late summer and early fall, the lake may undergo short-term warming. For example, in South Lake average surface temperatures during the winter months are approximately 54 ºF, while average surface temperatures in the summer are 67 ºF. During these warm periods, higher surface temperatures can contribute to weak, temporary thermal stratification within the lake (EDAW, 2004; SFPUC 2009). However, given the high rate of decomposition of algae at the bottom of the lake, chemical stratification may persist for longer than classical thermal stratification.

Wind

Wind provides one of the main mixing forces that can disrupt stratification patterns in a lake. A lake consists of layers or slabs of water, each of which is slightly different in temperature and thus density. Light breezes do not have sufficient energy to lift tons of water in slabs at a deeper depth, so only strong winds have much effect. The main energy of the wind does not go into mixing the slabs of water together but into pushing the surface slab horizontally around the lake. The motion of the upper layer creates a shear force between the uppermost water layer and the layer below causing friction and some small amount of vertical mixing. When the wind is strong, surface waves occur and create several forces that increase vertical mixing. Waves cause vertical oscillations of water that are transmitted down through the slabs to the lake bed. Wave height and vertical water oscillations depend mostly on wind strength. However, the transmission of motion from surface waves (wave height) decreases logarithmically with depth depending on wavelength (long wavelength waves stir deeper). In turn, wavelength depends on fetch, the distance over which the wind blows. Lake Merced is a small lake so wave lengths are small so that even strong winds do not mix very deeply. Analysis of Lake Merced has indicated that wind mixing conditions are dominant over solar heating and the lake is prone to unstable conditions that can easily be mixed by typical local wind conditions (EDAW, 2004).

In fairly shallow and cool lakes like Lake Merced the water column may seem to be well mixed as shown by temperature (EDAW, 2004) but still shows chemical stratification with low DO and pH at the bottom and higher DO and pH at the surface. This is because although the lake is mixing, the rate of mixing and transport of chemicals from surface to bottom is too slow to overcome the rate of biological reactions like photosynthesis and respiration described above. Put simply, there are not enough windy days to keep Lake Merced chemically mixed even though top and bottom temperatures are fairly similar.

Depth

The depth of a lake influences the degree of interaction between surface and bottom layers. In shallow lakes, wind mixing is usually strong enough to mix a lake from top to bottom and prevent stratification. Deeper lakes tend to exhibit stronger patterns of stratification because there is less interaction between the surface and bottom. With depths ranging from 2 to 21 feet, Lake Merced is classified as a shallow lake. Therefore mixing the water column usually prevents development of strong, persistent thermal stratification. There is sufficient depth in the deeper waters to allow persistent chemical stratification, given the eutrophic nature of the lake and the high rates of algal growth and decomposition.

Nutrient Enrichment

Nutrient dynamics are important to water quality as high concentrations of nutrients can lead to eutrophication, which in turn can cause a variety of water quality impacts such as increased algal biomass, depletion of dissolved oxygen, fish kills and loss of biodiversity. The degree of algal growth is usually restricted by the amount of the most limiting nutrient, which in aquatic systems is usually nitrogen or phosphorus. The limiting nutrient in some systems can be determined by looking at the ratio of N to P. However, in eutrophic systems when nutrient concentrations are high, algal biomass may become so large that available light for photosynthesis becomes the limiting factor (Pepper et al., 2006).

There have been several water quality reviews and assessments conducted for Lake Merced over the past 10 years (See **Appendix B -** Inventory of Documents Related to Lake Merced and Vista Grande Watershed Water Quality). In general, nutrient concentrations within Lake Merced are in the range of eutrophic systems and Secchi depths average less than 2 feet. Over the time period of 1997 to 2009, average total phosphorus concentration was 0.149 mg-P/L, the average orthophosphate concentration was 0.061 mg-PO4/L, the average ammonia concentration was 0.05 mg-N/L, the average nitrate concentration was 0.031 mg-NO_3/L, and total Kjeldahl nitrogen was 3.67 mg/L (SFPUC, 2009). As shown in **Table 5**, nutrient concentrations in South Lake are indicative of a eutrophic lake.

TABLE 5
COMPARISON OF SOUTH LAKE NUTRIENT CONCENTRATIONS TO TROPHIC STATE INDICATORS

Water Quality Variable	Average Concentration in South Lake (µg/L)[1]	Trophic state boundary level (µg/L)		Predicted Trophic State for South Lake
		Cooke & Welch	Horne	
Total Phosphorus	149	>28 Mesotrophic >100 Hyper-eutrophic	> 32	Strongly Eutrophic
Total Inorganic Nitrogen (nitrate + ammonium)	81	Not Considered	> 110 Eutrophic	Eutrophic
Secchi depth (meters	0.55 m	< 2 m Eutrophic < 1 m Hyper-eutrophic	< 2.6 m Eutrophic	Strongly Eutrophic
Chlorophyll a	26	> 9 Eutrophic > 25 Hyper-eutrophic	> 7.9	Strongly Eutrophic

NOTE:
1 Average concentrations (1997-2009); SFPUC, 2010

SOURCE: Cooke & Welch, 2011; Horne, 1996

Conclusions regarding nutrient limitation within the lake have varied over time, depending on report authors, and on the methodology used for making the determination. In 2004, EDAW analyzed nutrient levels at Lake Merced and found that based on the total nitrogen to total phosphorus ratio it appeared that Lake Merced may have been phosphorus-limited. However, when the N:P ratio was analyzed based on the bioavailable inorganic nutrients (nitrate, ammonia, and orthophosphate), instead of total Kjeldahl nitrogen (TKN includes the minimally biologically available organic nitrogen fraction that tends to dominate in the lake), along with nitrate, and total phosphorus, EDAW determined that the Lake would appear to be co-limited by nitrogen and phosphorous (EDAW, 2004).

In 2007, RMC did an analysis of nutrient levels at Lake Merced and, using the bioavailable forms of nitrogen and phosphorus (NH3-N + NO3-N:Ortho P), found the Lake to be strongly nitrogen-limited (RMC, 2007). Kennedy/Jenks (2010) using total nitrogen (TKN + nitrate) and 100% of total phosphorous to calculate the N:P ratio, estimated that the Lake has been nitrogen-limited since 2005. Since Lake Merced has high levels of organic nitrogen, it is more appropriate to analyze the bioavailable nitrogen to bioavailable phosphorus ratio. This is because algae can uptake the inorganic forms of nitrogen more easily. Bioavailable nitrogen is the sum of nitrate and ammonia, which is referred to as total inorganic nitrogen (TIN). Bioavailable phosphorus has been estimated at approximately 80% of total phosphorus. Using the TIN:80% of Total P ratio as the limiting nutrient indicator, one would conclude that the Lake is currently strongly nitrogen limited and has been since 2000 (RMC, 2007).

The debate over whether nitrogen and/or phosphorus may be the more limiting nutrient is somewhat academic given that the rate of supply of nutrients present has been more than sufficient to render the lake eutrophic (Table 5) and support high concentrations of algae year-round in Lake Merced. Although over a dozen algal species have been identified in Lake Merced, the four most prominent algal species are *Oscillatoria*, *Anabaena*, *Melosira*, and *Mougotia*. O*scillatoria* and *Anabaena* are cyanobacteria (blue-gree algae) and have the unique advantage of controlling their buoyancy and thus their position in the water column, optimizing exposure to sunlight and available nutrients. *Anabaena* has the additional ability to fix nitrogen (N+), thus giving it a distinct advantage should inorganic forms of nitrogen (NO3 - and NH4 +) become limited. *Melosira* is a diatom, while *Mougotia* is a green algae. By far *Oscillatoria* is the dominant phytoplankton species in both North and South Lakes with *Oscillatoria* plankton counts two to three orders of magnitude greater than the other species (MSC, 2001).

All of the prominent algae species are characteristic of eutrophic waters. The various trophic status indicators also indicate the presence of eutrophic conditions in Lake Merced. The year-round dominance by *Oscillatoria* is not fully understood, but is probably a function of several factors including a year-round mild coastal climate, steady supply of sufficient nitrogen (nitrate) possibly through groundwater contributions (inflows) to the system, limited light transparency (partly due to phytoplankton), and internal nutrient cycling possibly due to anoxic conditions in bottom waters combined with or followed by frequent mixing to make sediment released nutrients available in the upper water column. Although both *Oscillatoria* and *Anabaena contain gas vacuoles which allow them* to regulate depth in the water column (MSC, 2001), only *Anabaena* is large enough for this to play an important role in Lake Merced. The regulation of sinking and rising is controlled by the gas vacuoles (lowers cell density) but more so by the colony size. Because it can rise easily in thermally stratified waters, *Anabaena* is favored over *Oscillatoria*, for example in most of the warmer East Bay reservoirs. When the water column is frequently mixed, *Anabaena's* buoyancy is no longer an advantage. In these circumstances colony size becomes a disadvantage if a nutrient is limiting since smaller algae have a more favorable surface area to volume ratio. Since uptake of nutrients is a partially a function of cell surface area, the smaller species can grow faster in mixed conditions. The small single filaments of *Oscillatoria* are easily stirred lower in the water column depth by the wind driven mixing and rise slowly in calm periods. Thus this genus is ideally suited for the weakly stratified conditions of Lake Merced, provided that the supply of nutrients is adequate. *Oscillatoria* is common in similar cool water, nutrient-rich shallow lakes in many places in the world.

The results of the previous studies discussed above indicate that there is a need for continued nutrient and related data collection and assessment to understand and track the factors controlling the extent of algal growth (eutrophication), stratification, and associated impacts on dissolved oxygen and pH conditions in the surface and bottom levels of the Lake. Potential sources of N and P in the Lake Merced system are discussed below.

External Nutrient Sources

External sources of nutrient inputs to Lake Merced include non-point watershed sources discharged via stormwater runoff, groundwater, atmospheric deposition, organic matter decomposition and biological nitrogen fixation.

Areas within the watershed that serve as non-point sources of nutrients to Lake Merced include Harding Park Golf Course, adjacent roadways, surrounding open space areas and occasional overflows from the Vista Grande Canal. In the past, Harding Park Golf Course used a complete fertilizer (containing N, P and K) at an application rate of 6 lbs of N per 1000 ft^2. Phosphorus is no longer applied to turf areas and up to 95% of stormwater from the golf course now drains to a basin under the driving range (EDAW, 2004; SFPUC, 2011). However, it is possible that past runoff could have contributed to buildup of nutrients in lake sediments (EDAW, 2004). Groundwater within the Westside basin has high levels of nitrate that may contribute to Lake Merced (SFPUC, 2011; EDAW, 2004). Previous studies suggest that general watershed sources are significant contributors to nutrient levels in the lake; however, additional data is needed to assess contribution of individual sources (EDAW, 2004).

Internal Nutrient Sources

Internal sources of nutrients in Lake Merced include sediments and decomposition of organic matter. Bottom sediments in lakes can be a large reservoir for nutrient storage. Under aerobic conditions, an oxidized surface layer forms on the sediment acting to retain nutrients. However, under anoxic conditions created during periods of stratification or low mixing rates, nutrients may be released from sediments into the water column, contributing to eutrophication. The degree of nutrient release is dependent upon lake conditions. Warmer waters promote more internal loading of nutrients and longer periods of anoxia contribute more than short ones.

Nutrient Removal

Nitrogen in aquatic systems may exist in several forms: dissolved nitrogen gas (N2), organic nitrogen incorporated into organic matter, ionized (NH4 +) and undissociated ammonia (NH_4OH), dissolved ammonia gas (NH_3), nitrite ion (NO_2^-), and nitrate ion (NO_3^-). Under aerobic conditions, bacteria mediate the oxidation of ammonia to nitrate (with an intermediate step as nitrite) in a process called nitrification. In the nitrification reaction, 1.0 g of ammonia consumes 4.57 g of oxygen. In the absence of oxygen, bacteria mediate the reduction of nitrate to nitrogen gas in the process of denitrification (MSC, 2001). Since denitrification is a microbial mediated process, it slows at cold temperatures. This is a process where additional ammonia and/or nitrate added to the Lake would be removed from the system to the atmosphere and therefore not be available to support additional algal (or other aquatic plant) growth. However, under most lake conditions, nitrate is present in very low concentrations near the anoxic sediments so that denitrification rates are very low. Artificial lake mixing can increase moving nitrate from the free water to the sediment zone and increase denitrification. Phosphorus is typically adsorbed onto particulates (sediments) and may therefore be removed via sedimentation of the associated particulate in addition to uptake by aquatic plants. However, on decay of the plants or organic particles, phosphate is once again released to the water.

Lake Merced Beneficial Uses, Water Quality Objectives, and Clean Water Act Section 303(d) Impaired Waterbodies List

This section describes the beneficial uses that Lake Merced is designated to support, the key water quality objectives applicable to those uses, and the history of the U.S. Environmental Protection Agency (EPA) putting the Lake on the Section 303(d) list as being impaired for elevated pH and low DO.

Beneficial Uses

The San Francisco Bay Regional Water Quality Control Board Basin Plan (Basin Plan) designates Lake Merced as supporting the following beneficial uses:

- Cold Freshwater Habitat (Cold)
- Warm Freshwater Habitat (Warm)
- Fish Spawning (Spwn)
- Wildlife Habitat (Wild)
- Water Contact Recreation (Rec1)
- Noncontact Water Recreation (Rec2)
- Municipal And Domestic Supply (Mun)

The full Basin Plan definitions of each of these uses are provided below.

Cold Freshwater Habitat (COLD)

Uses of water that support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. Cold freshwater habitats generally support trout and may support the anadromous salmon and steelhead fisheries as well. Cold water habitats are commonly well-oxygenated. Life within these waters is relatively intolerant to environmental stresses.

Often, soft waters feed cold water habitats. These waters render fish more susceptible to toxic metals, such as copper, because of their lower buffering [or metal chelation] capacity.

Warm Freshwater Habitat (WARM)

Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. The warm freshwater habitats supporting bass, bluegill, perch, and other panfish are generally lakes and reservoirs, although some minor streams will serve this purpose where stream flow is sufficient to sustain the fishery. The habitat is also important to a variety of nonfish species, such as frogs, crayfish, and insects, which provide food for fish and small mammals. This habitat is less sensitive to environmental changes, but more diverse than the cold freshwater habitat, and natural fluctuations in temperature, dissolved oxygen, pH, and turbidity are usually greater.

Fish Spawning (SPWN)

Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. Dissolved oxygen levels in spawning areas should ideally approach saturation levels. Free movement of water is essential to maintain well-oxygenated conditions around eggs deposited in sediments. Water temperature, size distribution and organic content of sediments, water depth, and current velocity are also important determinants of spawning area adequacy.

Wildlife Habitat (WILD)

Uses of waters that support wildlife habitats, including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl. The two most important types of wildlife habitat are riparian and wetland habitats. These habitats can be threatened by development, erosion, and sedimentation, as well as by poor water quality.

Water Contact Recreation (REC1)

Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs. Water contact implies a risk of waterborne disease transmission and involves human health; accordingly, criteria required to protect this use are more stringent than those for more casual water oriented recreation. Excessive algal growth has reduced the value of shoreline recreation areas in some cases, particularly for swimming.

Where algal growths exist in nuisance proportions, particularly blue-green algae, all recreational water uses, including fishing, tend to suffer. One criterion to protect the aesthetic quality of waters used for recreation from excessive algal growth is based on chlorophyll a [the green pigment in all plants that is the start of the photosynthetic process].

Noncontact Water Recreation (REC2)

Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. Water quality considerations relevant to noncontact water recreation, such as hiking, camping, or boating, and those activities related to tide pool or other nature studies require protection of habitats and aesthetic features. In some cases, preservation of a natural wilderness condition is justified, particularly when nature study is a major dedicated use. One criterion to protect the aesthetic quality of waters used for recreation from excessive algal growth is based on chlorophyll a.

Municipal and Domestic Supply (MUN) (Potential Emergency Use)

Uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply. The principal issues involving municipal water supply quality are (1) protection of public health; (2) aesthetic acceptability of the water; and (3) the economic impacts associated with treatment or quality related damages.

The health aspects broadly relate to: direct disease transmission, such as the possibility of contracting typhoid fever or cholera from contaminated water; toxic effects, such as links between nitrate and methemoglobinemia (blue babies); and increased susceptibility to disease, such as links between halogenated organic compounds and cancer.

Aesthetic acceptance varies widely depending on the nature of the supply source to which people have become accustomed. However, the parameters of general concern are excessive hardness, unpleasant odor or taste, turbidity, and color. In each case, treatment can improve acceptability although its cost may not be economically justified when alternative water supply sources of suitable quality are available.

Published water quality objectives give limits for known health related constituents and most properties affecting public acceptance. These objectives for drinking water include the U.S. Environmental Protection Agency Drinking Water Standards and the California State Department of Health Services criteria.

SFBRWQCB, 2010.

Of the above designated uses, the uses that are most directly sensitive to the degree of eutrophication and stratification and associated pH and particularly DO levels within Lake Merced are uses related to habitat quality for aquatic organisms – specifically, COLD, WARM, SPWN and WILD. It should be noted that under stratified conditions, the respective uses may exist to differing degrees depending on the relative temperature, DO and pH in the separated upper and lower portions of the Lake. REC-1 and REC-2 uses could also potentially be affected to the extent that algal growths exist in nuisance proportions that interfere with recreational activities or that the aesthetic quality of Lake Merced is adversely impacted from excessive algal growth. Swimming is prohibited in Lake Merced by CCSF so the potential excessive algal growth impacts would only apply to the other REC-1 and REC-2 uses.

The Lake is designated as a potential MUN source and SFPUC has designated the Lake solely as an emergency supply, only used following a catastrophic event, and only under the conditions of a "boil water" order. Given these restrictions, this assessment of potential impacts from addition of Vista Grande stormwater to South Lake will be limited to the other beneficial uses.

Water Quality Objectives

The Basin Plan contains narrative and numeric water quality objectives (WQO) that apply to most waters in the Region and are intended, in part, to ensure that Beneficial Uses are protected. The WQO for biostimulatory substances (aka nutrients), DO, and pH are cited below. It is pertinent to note that there are efforts underway that may result in adoption of numeric nutrient WQO, but that currently only the narrative WQO below applies.

Biostimulatory Substances

Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses. Changes in chlorophyll a and associated phytoplankton communities follow complex dynamics that are sometimes associated with a discharge of biostimulatory substances. Irregular and extreme levels of chlorophyll a or phytoplankton blooms may indicate exceedance of this objective and require investigation.

Dissolved Oxygen

For nontidal waters, the following objectives shall apply:

Waters designated as:

Cold water habitat	7.0 mg/l minimum
Warm water habitat	5.0 mg/l minimum

The median dissolved oxygen concentration for any three consecutive months shall not be less than 80 percent of the dissolved oxygen content at saturation.

Dissolved oxygen is a general index of the state of the health of receiving waters. Although minimum concentrations of 5 mg/l and 7 mg/l are frequently used as objectives to protect fish life, higher concentrations are generally desirable to protect sensitive aquatic forms. In areas unaffected by waste discharges, a level of about 85 percent of oxygen saturation exists. A three month median objective of 80 percent of oxygen saturation allows for some degradation from this level, but still requires a consistently high oxygen content in the receiving water.

pH

The pH shall not be depressed below 6.5 nor raised above 8.5. This encompasses the pH range usually found in waters within the basin. Controllable water quality factors shall not cause changes greater than 0.5 units in normal ambient pH levels.

SFBRWQCB, 2010

Section 303(d) Listing

Under Section 303(d) of the Clean Water Act, states are required to develop a list of impaired waters, defined as water bodies that do not meet state water quality standards, every two years. Water quality standards include designated Beneficial Uses and Water Quality Objectives (40 CFR 131.3(i)).

On November 28, 2001, during the 2002 303(d) listing process, Lake Merced was included on the Regional Water Board's "Preliminary List of Waterbodies and Pollutants" for "Low Dissolved Oxygen/Organic Enrichment." This was in Table 5 in the Board item approving transmittal of the 2002 303(d) list to the State Water Board. The accompanying staff report (p. 35) stated that:

> *"Regional Board staff recommends that DO and pH be monitored systematically by a public agency such as the SFWD, the San Francisco Public Utilities Commission, or other stakeholder. This monitoring should be conducted at the same sites as the SFWD program plus additional sites within the different portions of the lake, and more frequently than before, continuously where resources allow, to assess whether the lake is truly impaired due to lack of DO or elevated pH. In the next listing cycle the Regional Board will re-evaluate DO and pH information, including the 1997-2000 data, and either accept or reject an impairment determination for DO and pH."*

On February 28, 2003 the State Water Board (SWB) transmitted the State's 2002 303(d) list to USEPA. The SWB included Lake Merced on the "Monitoring List" (Table 7) for "Low Dissolved Oxygen." This did not require development of a TMDL. Waters were placed on the Monitoring List where "*minimal, contradictory or anecdotal information suggests standards are not met but the available data or information is inadequate to draw a conclusion*."

On June 5, 2003 the USEPA partially approved and partially disapproved California's 2002 Section 303(d) list. USEPA added Lake Merced to the 303(d) list for DO and pH. As their rationale they stated in part that:

> *"The San Francisco Bay Basin Plan includes numeric standards for dissolved oxygen and pH that are applicable to this water (San Francisco Bay RWQCB, 1995, p. 3-3). EPA's analysis of available data in the State's record found that 46-83% of available samples exceed the existing numeric water quality standards for DO and pH in Lake Merced, depending upon the monitoring station (n=14). The State has not provided a sound rationale for concluding that the water quality standards for pH and DO are not exceeded. The stated rationale that the available data may not be representative is unpersuasive.*
>
> *Data were collected at several locations over a recent multi-year time frame. The rationale that samples taken at depth should not be considered and that analysis only of surface samples demonstrates attainment is also unpersuasive because the Basin Plan includes no provisions indicating that these standards are to be applied only at the surface. EPA concludes that absent Basin Plan language to the contrary, these standards apply at all water depths. Based on these considerations, EPA has determined that this water should be identified for inclusion on the list for pH and DO.*

EPA is establishing a low priority for this listing based on the considerations that no specific beneficial use impairments have been associated with DO and pH problems in the Lake, and that additional monitoring is warranted to verify these listings prior to developing TMDLs.*"* (emphasis added)

Lake Merced remains on the final California 2008-2010 Section 303(d) list (as approved by USEPA October 11, 2011) as impaired for dissolved oxygen and pH caused by unknown sources. A TMDL is shown to be completed by 2019.

The SWB on adopted September 30, 2004 a *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List* (Resolution No. 2004-0063). This Policy provides the currently applicable guidance (that was not in place at the time of the original Lake Merced listing) on criteria to use for adding and removing waterbodies from the 303(d) list including using a weight-of-evidence based approach.

Subsequently, the SWB on June 16, 2005 adopted the "*Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options*" (Resolution No. 2005-0050). This policy provides alternatives to TMDLs for addressing 303(d) listings. As stated on page 6:

> *"If a solution to an impairment is being implemented by a regulatory action of another state, regional, local, or federal agency, and the Regional Board finds that the solution will actually correct the impairment, the Regional Board may certify that the regulatory action will correct the impairment and if applicable, implement the assumptions of the TMDL, in lieu of adopting a redundant program."*

This policy also provides a rationale for considering complex and variable parameters in environments where there is low DO due to "natural conditions" (e.g., sediment/benthic oxygen demand, limited flushing, diurnal fluctuation, seasonal stratification, etc.). The policy (p. 3, item B) states that:

> *"If the failure to attain standards is due to the fact that the applicable standards are not appropriate to natural conditions, an appropriate regulatory response is to correct the standards*"

Daly City intends to work with Water Board staff and the SFPUC to reassess the existing 303(d) listing and to develop potential alternatives to address the current listing based on the above SWB policies. A brief synopsis of these two SWB policies prepared by the Central Valley RWQCB is presented in **Appendix C**.

Lake Management Plan

Daly City, in cooperation with the SFPUC, intends to develop a Lake Management Plan which would include a phased program of measures intended to maintain and where feasible improve the water quality of South Lake and Lake Merced in general. As the first step in developing the Lake Management Plan, Daly City, in cooperation with the SFPUC, has prepared a preliminary list of potential actions intended to help improve water quality in South Lake. The list includes watershed source control measures, treatment options, and lake management options which can be used singularly or collectively. This preliminary list has been expanded into the attached matrix that identifies the intended benefits of each action, the potential improvement of DO and pH levels, application and feasibility considerations, and whether additional evaluation is warranted at this time (**Appendix D**).

Lake Merced Project Impact Assessment Approach

This section presents the operational aspects of the proposed project, how project operational criteria may influence future stratification and eutrophication conditions and associated pH and DO levels in Lake Merced, and a framework (set of problem statements) to guide efforts to assess the potential effects of the project on existing conditions in the Lake.

Project Operational Variables

The proposed project would reroute dry and wet season flows from the Vista Grande Canal into Lake Merced and would consist of several operating options dependent upon flow and antecedent conditions. In all options, water would be screened using a debris screening system to trap all material > 5 mm in diameter. During dry weather and low wet weather flow events, authorized non-stormwater and stormwater would be screened for trash and debris and then routed through a constructed wetlands natural treatment system before entering South Lake Merced. Specified winter flows that exceed the capacity of the wetlands natural treatment system would also be routed to South Lake Merced. Finally, remaining storm water flows would continue to be routed to the Pacific Ocean via the Vista Grande Canal and Tunnel (Jacobs Associates, 2011).

There are several factors that affect the assessment of potential project impacts on South Lake Merced. Available information indicates that the periods of greatest stratification, highest algal growth and biomass (blooms) and highest surface water pH values and lowest bottom water DO values occur during the summer and fall seasons. These are the periods when there would be the least addition of Vista Grande Canal flow to South Lake (only dry weather baseline flow). These baseline flows would be routed through the constructed treatment wetlands prior to being introduced into the Lake.

The majority of stormwater flow (and associated loadings) would be introduced during the winter wet season months, the period of lowest temperatures and sunlight, lowest algal growth potential, and lowest potential for stratification. Methods will need to be developed to evaluate the fate of the nutrients introduced during these wet season months and their impact on algal growth potential during the summer and fall months.

The project will have the ability to control the timing and volume of stormwater diverted to the ocean. These yet to be developed operational criteria will control the volume and loadings introduced to South Lake. Seasonal volume and loading estimates will need to be determined in order to evaluate impacts on Lake elevations and resultant potential impacts on the degree of stratification, algal growth, pH and DO levels. To meet the preliminarily identified lake level restoration targets, lake levels could change by approximately 2-3 feet seasonally, depending on climatic and operational factors (e.g., threshold diversion flow rates, groundwater pumping rates).

The Vista Grande Canal water is proposed to be introduced at the south end of South Lake. It is assumed that the wet season Canal water will blend with the greater volume of South Lake water fairly quickly and become indistinguishable from the background South Lake water quality. Modeling would need to be conducted if quantifying the extent of this mixing area was determined to be to be an issue of concern. Localized impacts from the wetlands treated, low volume dry season flows are expected to be minimal. The yet to be determined range of increase in lake elevation from the project will inundate areas of existing riparian habitat. Depending on the extent and duration of seasonal inundation, this could impact localized DO concentrations (due to anaerobic decay of inundated organic matter).

The yet to be determined range of increase in Lake elevation from the project may also potentially affect the timing, duration, and magnitude of stratification that could occur. Calculations and/or modeling would need to be conducted (see EDAW 2004) to evaluate the effects of variable lake levels on stratification.

Stratification and Nutrients

If the proposed project is not implemented, current stratification conditions would likely persist into the future. Without additional water input, it is possible that lake levels could decrease to as low as -15 feet City Datum, depending on rainfall conditions.

Under the preliminary target elevation levels of 5.5 to 9.5 feet City Datum, Lake Merced would still be considered a shallow lake. Current environmental conditions of cool weather, frequent marine layer and predominant winds are not expected to change. Therefore, raising lake levels to the maximum target level of 9.5 feet City Datum would not be expected to substantially change Lake Merced's current pattern of weak, intermittent stratification (EDAW, 2004). However, this increase may result in slightly longer period of weak stratification that would affect a larger area of the lake bed. As a result, nutrient flux from the bottom sediments may increase due to potentially longer periods of anoxia in bottom waters. Further analysis of the extent of anoxia in bottom waters is needed to evaluate the extent of changes in internal nutrient cycling, eutrophication and levels of dissolved oxygen (EDAW, 2004).

The EDAW (2004) report assessed impacts associated with raising lake levels by 4 to 8 feet above the lake level that existed at the time (which were establish by a 2002 survey at a 0.5 feet city datum). The lake level is currently around 6.5 feet city datum (Figure 1). As such, environmental changes contemplated in the report have already occurred (such as inundation of shoreline vegetation, and changes in aquatic habitat).

The proposed project anticipates Lake elevations being maintained in the range of 5 – 9.5 feet. Recent elevations (mid-2011) were in the range of 6.9 feet. Therefore the potential maximum elevation increase would be just over 2.5 feet above current (and recent – see Figure 1) conditions.

If the proposed project is not implemented, future nutrient dynamics within the lake would likely be similar to historical trends.

If the proposed project were to be implemented, it is possible that nutrient input from Vista Grande Canal stormwater could raise nutrient levels within the lake and result in increased eutrophication and decreased dissolved oxygen. However, if the lake is currently light limited, then additional nutrient input may not stimulate additional algal growth. In order to determine the possible range of range of nutrient loading and subsequent effects on Beneficial Uses, further analysis of nutrient dynamics in the stormwater and Lake Merced is needed.

Problem Statements

The project team has developed several narrative (problem) statements intended to help focus the direction of the assessment of potential water quality impacts of the proposed project on South Lake Merced.

a. What analyses will be conducted to evaluate the likelihood, and if so extent, to which the proposed controlled diversion of stormwater to South Lake Merced may result in exceedance of water quality standards?

b. Are beneficial uses currently impaired by existing DO and pH levels? While Lake Merced is listed for DO and pH, there is no documentation of beneficial use impairment. In creating the listing, EPA noted that “no specific beneficial use impairments have been associated with DO and pH problems in the Lake, and that additional monitoring is warranted to verify these listings prior to developing TMDLs (EPA, 2003).

c. What processes/variables influence DO and pH level in the Lake? (e.g. algal production, stratification, lake morphology, lack of flushing, groundwater inputs, and vegetation restriction of mixing).

d. What is the sensitivity of the Lake to additional nutrient inputs? What are the key drivers/factors that influence biological responses to nutrient loads?

e. How will increasing the depth of the Lake affect stratification and other conditions (i.e. vegetation inundation) that could affect DO and pH levels.

f. What monitoring will be necessary to demonstrate that the proposed Lake Management Plan measures are successfully maintaining and where feasible improving dissolved oxygen and pH levels?

Monitoring Plans and Assessment Strategy

Monitoring Plans

Daly City has initiated the collection of water quality data to support analysis of the proposed project. Data has been collected according to the 2011Dry Season Water Quality Monitoring Plan, which was finalized with input from SFBRWQCB staff. Additional monitoring will be conducted according to the draft 2011-2012 Wet Season Water Quality Monitoring Plan.

In addition to water quality monitoring required for project evaluation, further monitoring data may be warranted to provide a broader characterization of DO and pH conditions in other portions of Lake Merced. This additional data would expand upon data collected to date through the SFPUC's quarterly monitoring program, and would support re-assessment of the 303(d) listing for DO and pH. Plans to collect this data would need to be developed by Daly City and SFPUC in consultation with Water Board staff.

Assessment Strategy

Based on input provided by Water Board staff, Daly City is proposing an assessment strategy focused on evaluating the project in light of the current 303(d) listing. The assessment strategy consists of the evaluation of the key limnological conditions of South Lake, the potential for project-related changes in these existing conditions, and identification and evaluation of other watershed and lake management actions that will maintain and where feasible improve water resource management in general and DO and pH levels in Lake Merced specifically. These tasks are outlined below. Further development of the assessment strategy will be provided by Daly City in consultation with the SFPUC and Water Board staff.

Existing Conditions

This task will expand on the system understanding provided above, and will form the basis of the project evaluation.

- Description of Lake Merced
  - Lake and Watershed Characteristics
  - Climate and Precipitation
  - Hydrology
- Historic and Existing Water Quality
  - Analysis of existing water quality data:
    - SFPUC Quarterly Monitoring Data
    - Vista Grande 2011 Dry Season Monitoring Data
    - Vista Grande 2011-2012 Wet Season Monitoring Data
- Processes Affecting Lake Water Quality
  - Stratification
  - Nutrient Enrichment
- Regulatory Setting
  - Beneficial Uses
  - Water Quality Objectives
  - 303(d) Listing

Project Evaluation

- Describe project effects on Lake Merced
    - Description of diversion and lake level scenarios
    - Monthly diversion for each scenario
    - Water balance with project
    - Vista Grande Water Quality
        - Summarize dry and wet season data
            - Flow, temp, DO, pH
            - Key constituent levels
        - Estimate average/median concentration of key constituents
    - Estimate pollutant removal rate of proposed treatment wetland
- Assess changes in key lake processes:
    - Stratification
        - Develop mixing model to assess changes in lake mixing for various depths, including the existing elevation and a range of potential with-project conditions
        - Address affect of lakes levels on stratification
        - Address chlorophyll levels and secchi depth
    - Nutrient Enrichment, Productivity, and DO and pH
        - Estimate change of key nutrient concentrations in lake water (mass balance calculation).
        - Inundation of shoreline vegetation
        - Estimate potential change in DO and pH levels
        - Address change in water clarity (secchi depth)
- Estimate changes to existing water quality for other constituents:
    - Bacteria
        - Estimate potential change in bacteria levels from 1) stormwater, and 2) wetland discharge
        - Estimate dilution and die-off
    - Metals (copper, lead, nickel, zinc)
        - Compare concentrations within stormwater and lake water
- Fisheries Evaluation

- Evaluate potential effects to fish habitat including changes in lake stratification and DO levels

Potential Watershed and Lake Management Actions

- Identify list of potential watershed and lake management actions that would improve DO and pH levels in South Lake Merced.
- Evaluate the feasibility (including cost of implementation and maintenance) and efficacy of potential watershed and lake management actions to improve DO and pH conditions in South Lake Merced.
- Develop Lake Management Plan (water quality monitoring program, watershed and lake management actions, implementation timeline).

In addition, Daly City intends to work with Water Board staff and the SFPUC to assess the existing 303(d) listing and determine potential alternatives for a future listing cycle.

References

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Problem Statement:

How might the contribution of Vista Grande Stormwater to South Lake Merced measurably affect existing water quality conditions and beneficial uses?

Boundaries of the Study:

Spatial – The study will focus on South Lake Merced in the vicinity of the body of water that will be directly influenced by the introduction of Vista Grande stormwater. Any potential effects to the remaining areas of Lake Merced (North, East and Impound Lakes) are expected to be minimal due to mixing with background South Lake water and limited connectivity between the lakes.

Temporal – Data collection will occur within the dry and wet seasons to characterize seasonal and varying storm event water quality conditions.

DO and pH Assessment

Questions:	Information Needed:	Potential Analytic Approaches:
a. Are beneficial uses currently impaired by existing DO and pH levels? While Lake Merced is listed for DO and pH, there is no documentation of beneficial use impairment. In creating the listing, EPA noted that "no specific beneficial use impairments have been associated with DO and pH problems in the Lake, and that additional monitoring is warranted to verify these listings prior to developing TMDLs" (EPA, 2003).	• Develop more detailed understanding of DO and pH levels in South Lake. Expand on quarterly monitoring conducted by SFPUC. • Assess existing status of beneficial uses that could be impaired by existing DO and pH levels (including aquatic habitat and recreation). • Characterize existing aquatic habitat and life. • Determine DO and pH levels in Vista Grande stormwater.	• Estimate DO and pH levels in South Lake with and without the project. Specifically, assess how contributing factors would be affected by the project (e.g. algal production, stratification, lake morphology, lack of flushing, groundwater inputs, and vegetation restricting mixing).
b. What processes/variables influence DO and pH level in the Lake? (e.g. algal production, stratification, lake morphology, lack of flushing, groundwater inputs, and vegetation restriction of mixing).	• Identify the key factors affecting DO and pH levels in South Lake Merced. This includes the limiting factors of algal growth which affects DO and pH levels. • Determine existing lake productivity.	
c. What is the sensitivity of the Lake to additional nutrient inputs? What are the key drivers/factors that influence biological responses to nutrient loads? 1. What are the internal and external sources of nutrients in South Lake Merced? 2. What is the relative nutrient loading to South Lake from internal versus external sources? 3. Is algal production in the Lake limited by nutrients or other factors (i.e. light)? 4. To what concentrations would nutrients have to be reduced to become limiting? 5. How would Vista Grande stormwater discharges affect nutrient concentrations in the Lake?	• Determine duration and extent of low DO conditions occurring as a result of stratification. • Determine nutrient levels in Vista Grande Stormwater. This information is needed to assess the potential to increase algal growth. • Characterize potential nutrient sources to South Lake.	• Estimate nutrient limitations in South Lake Merced with and without the project. Determine the extent to which the project may increase available nutrients (i.e. orthophosphate, nitrate, ammonia). If the project would significantly change levels of bioavailable nutrients, estimate expected change in lake productivity, and any associated impact to beneficial uses. • Evaluate impacts under different lake level operational scenarios. • Estimate nutrient reduction of proposed treatment wetland under different operational scenarios.
d. How will increasing the depth of the Lake affect stratification and other conditions (i.e. vegetation inundation) that could affect DO and pH levels.	• Identify the key factors affecting lake stratification. • Identify the magnitude, extent and duration of lake stratification.	

Data Required:

- Levels of DO, pH and temperature in South Lake.
- Concentrations of key constituents in Vista Grande stormwater and South Lake Merced, consisting of:
  - Nitrate
  - Ammonia
  - Total Kjeldahl Nitrogen (TKN)
  - Total Phosphorus
  - Orthophosphate
  - COD
  - BOD
  - TSS
  - VSS
  - TDS
- Concentrations of Chlorophyll a in South Lake Merced.
- Secchi depth in South Lake Merced.
- Extent and duration of anoxic conditions in South Lake Merced.
- Nutrient flux to Lake Merced from Vista Grande Canal.
- Estimate relative magnitude of nutrient sources for South Lake Merced.
- Review and update aquatic habitat assessment.

Data Criteria:

- Hourly data to characterize diurnal patterns of DO, pH and temperature in South Lake.
- Include near shore and main water body monitoring, including surface to near bottom depth profiles
- Vista Grande Canal: Sufficient data should be collected to characterize flows and nutrient levels of waters proposed for diversion (baseflow and storm events). At a minimum, monthly baseflow sampling, and sampling of 6 wet season storm events. Data should be collected at multiple points in storm event hydrographs to characterize the variation of nutrient concentrations over the course of an event.
- South Lake: Sufficient data should be collected to characterize receiving water quality. At a minimum, twice-monthly sampling at 1 representative location in South Lake during summer/fall period when phytoplankton growth is peaking; at least once monthly during the winter/spring period when phytoplankton growth is limited.
- EPA methods and detection limits should be used to measure the following constituent levels at or below lowest historic levels:
  - Orthophosphate, nitrate, and ammonia (as N). *Rationale*: bio-available nutrients.
  - TKN and Total Phosphorus. *Rationale:* Total organic and inorganic concentrations.
  - Chemical Oxygen Demand. *Rationale:* Measure of total oxygen demanding substances. Informs assessment of DO.
  - Biochemical Oxygen Demand. *Rationale:* Measure of bio-available oxygen demanding substances. Informs assessment of DO.
  - Chlorophyll a. *Rationale:* Indicator of plankton/algal biomass.
  - Secchi depth (lake only). *Rationale:* As a measure of light penetration in water column.
  - Total Suspended Solids (TSS). *Rationale:* Indicator of solids loading.
  - Volatile Suspended Solids (VSS). *Rationale:* Indicator of organic matter in TSS.
  - Total Dissolved Solids (TDS): *Rationale:* Indicator of mineral content.

Bacteria/Pathogens

Questions:	Information Needed:	Potential Analytic Approaches:	Data Required:	Data Criteria:
e. How will discharge of Vista Grande stormwater affect indicator bacteria levels in South Lake? 1. What are existing indicator bacteria levels in South Lake? 2. What are the sources of indicator bacteria in South Lake? 3. What are the temporal bacteria levels within South Lake associated with stormwater runoff? 4. What are indicator bacteria concentrations in Vista Grande stormwater?	• Determine indicator bacteria levels in Vista Grande Stormwater. • Identify existing indicator bacteria levels in South Lake. • Estimate the relative contribution of fecal contamination of background versus human sources.	• Estimate indicator bacteria levels in South Lake with and without the project through a dispersion and die-off assessment. • Analyze for human bacteriodales.	• Concentrations of indicator bacteria in Vista Grande stormwater and South Lake Merced, consisting of: Escherichia coli (E. coli) Total Coliform Fecal Coliform Enterococcus Male Specific Bacteriophage (MS-2) Human Bacteriodales • Concentrations of Giardia and Cryptosporidium spp. (pathogens) and in Vista Grande stormwater and South Lake Merced.	• Vista Grande Canal: Sufficient data should be collected to characterize indicator bacteria/pathogen levels of waters proposed for diversion (baseflow and storm events). At a minimum, twice-monthly baseflow sampling (Giardia and Cryptosporidium once per month), and sampling of 6 wet season storm events. Data should be collected at multiple points in storm event hydrographs to characterize the variation of bacteria/pathogen concentrations over the course of an event. • South Lake – *Dry Season*: Sufficient data should be collected to characterize receiving water quality. At a minimum, twice-monthly sampling at 1 representative location in South Lake. Data should provide for the evaluation of project effects that during the dry season would be limited to discharges from the proposed treatment wetland. • South Lake – *Wet Season*: For a target of 6 wet season storm events, a series of 2 samplings should occur at 1 representative location in South Lake, one at the end of the event, and a second within 24 hours. Bacteria levels are expected to increase in the lake after storm events as the result of runoff, and that these levels then fall back as the result of bacteria die-off. This data will allow us to understand the existing conditions as they are related to the diversion of storm flows during the wet season. • Continuation of Pilot Diversions. If feasible during storm events of large magnitude and extent, conduct pilot diversion of Vista Grande stormwater to South Lake and monitor bacteria levels at near shore and offshore to characterize dilution. A series of 2 samplings should occur at a minimum of 3 locations in South Lake, one at the end of the event, and a second within 24 hours, to characterize bacteria die-off. Sampling of Vista Grande stormwater should occur during the diversion to characterize indicator bacteria/pathogen levels of the water diverted to South Lake.
f. What increased human health risk is associated with discharging Vista Grande stormwater to South Lake?	• Characterize the extent of use and exposure potential to recreational users (e.g. boaters, anglers). • Evaluate the incremental human health risk of exposure to various pathogenic agents of infection and/or disease.	• Conduct a Microbial Risk Assessment to evaluate the incremental human health risk from exposure to pathogens.		

Metals

Questions:	Information Needed:	Potential Analytic Approaches:	Data Required:	Data Criteria:
g. To what extent will the project increase metals loading to or concentration in South Lake?	• Determine levels of metals of concern in Vista Grande Stormwater. • Identify existing levels of metals of concern in South Lake to characterize receiving waters.	• Estimate loadings of metals of concern to South Lake with and without the project. • Estimate metals reduction of proposed treatment wetland.	• Concentrations of potential metals of concern in Vista Grande stormwater and South Lake Merced, consisting of: Lead (Pb) Copper (Cu) Nickel (Ni) Mercury (Hg) Zinc (Zn)	• Vista Grande Canal: Sufficient data should be collected to characterize levels of metal of concern in waters proposed for diversion (baseflow and storm events). At a minimum, twice-monthly baseflow sampling during the dry season, and sampling of 6 wet season storm events. • South Lake: Sufficient data should be collected to characterize receiving water quality. Twice-monthly sampling during the dry season and sampling of 6 wet season storm events at 1 representative location in South Lake. • EPA methods and detection limits should be used to measure the following constituent levels at or below lowest historic levels: Total and Dissolved Metals *Rationale*: Dissolved metals are more biologically available. Consistency with California Toxics Rule objectives. Total Mercury *Rationale*: Consistency with California Toxics Rule objectives. Hardness *Rationale*: The toxicity of metals depends on the hardness of the receiving waters.

REFERENCES:
U.S. Environmental Protection Agency (EPA), letter from Alexis Strauss, EPA Region 9 to Celeste Cantú, State Water Resources Control Board, June 5, 2003.

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Water Boards

San Francisco Bay Regional Water Quality Control Board

May 9, 2013
CIWQS Place ID 766747

Sent via electronic mail: No hard copy to follow

City of Daly City
333 90th Street
Daly City, CA 94015-1895
Attn.: Ms. Patricia Martel
Email. pmartel@dalycity.org

Subject: Concurrence with Proposed Regulatory Process for Vista Grande Drainage Basin Improvement Project, Lake Merced Alternative

Dear Ms. Martel:

We have reviewed the letter dated March 12, 2013, summarizing the proposed regulatory process for the Vista Grande Drainage Basin Improvement Project, Lake Merced Alternative (Regulatory Process Letter). In general, we concur with the regulatory process as proposed by the City of Daly City. However, we are providing clarifications to the Regulatory Process Letter to help improve the City's understanding of the process and our expected outcomes from the process.

Lake Management Plan

On page 2 of the Regulatory Process Letter, the text indicates that the Lake Management Plan (LMP) would specify best management practices (BMPs) to maintain and where feasible, improve the water quality of Lake Merced. We suggest "where feasible," be deleted from the objective in the LMP. Our expected outcome from implementation of the LMP is for the water quality of Lake Merced to improve. Although we agree that technical and logistical feasibility as well as cost considerations will need to be evaluated during the BMP selection process, our expectation is that implementing the LMP would improve the water quality of Lake Merced.

Basin Plan Amendment

On page 4 of the Regulatory Process Letter, the text indicates that we could recommend to the U.S. Environmental Protection Agency (USEPA) that Lake Merced be taken off the 303(d) list of impaired water bodies after (1) the LMP is implemented via an operational agreement between the City and the San Francisco Public Utilities Commission and (2) the Regional Water Board adopts site-specific dissolved oxygen and pH implementation provisions via a Basin Plan amendment. Although we agree with this approach, please note that any Basin Plan amendment would need to be approved by the State Water Board, the State Office of Administrative Law, and USEPA before we could recommend delisting Lake Merced. We would also need adequate evidence that Lake Merced water quality complies with the site-specific dissolved oxygen and pH implementation provisions.

Closing

If you have any questions, please contact Xavier Fernandez of my staff at (510) 622-5685 or by e-mail at xafernandez@waterboards.ca.gov.

Sincerely,

Digitally signed by Bruce H. Wolfe
Date: 2013.05.09 10:58:49 -07'00'

Bruce H. Wolfe
Executive Officer

cc: SFPUC. Steve Ritchie, SRitchie@sfwater.org
ESA, Josh Ferris, JFerris@esassoc.com
ESA, Alisa Moore, AMoore@esassoc.com

CITY OF DALY CITY
333 90TH Street
DALY CITY, CA 94015-1895

PHONE: (650) 991-8000

March 12, 2013

San Francisco Bay Regional Water Quality Control Board
Mr. Bruce H. Wolfe, Executive Officer
1515 Clay Street, Suite 1400
Oakland, CA 94612

Subject: Draft - Proposed Regulatory Process for the Vista Grande Drainage Basin Improvement Project

Dear Mr. Wolfe,

I appreciate the time and attention that you and your staff have committed to the preliminary review of the Vista Grande Drainage Basin Improvement Project. This project is critical to resolving ongoing flooding issues in Daly City and provides an important means to improve the use, enjoyment, and health of Lake Merced. Daly City has worked closely with the San Francisco Public Utilities Commission (SFPUC), other stakeholders, and Regional Water Quality Control Board (RWQCB) staff in developing the Lake Merced Alternative, which if approved, would divert selected storm flows from the Vista Grande Canal to Lake Merced, reconnecting a significant portion of the lake's original recharge area and thereby providing a reliable water supply to raise and maintain lake levels.

Daly City is committed to developing the Lake Merced Alternative and, if approved, operating it in a manner that protects the water quality and beneficial uses of Lake Merced. Daly City and the SFPUC expect that implementation of the project, in conjunction with the proposed Lake Management Plan, would improve the health of Lake Merced over time. To ensure the attainment of dissolved oxygen (DO) and pH standards, the RWQCB, Daly City, and SFPUC have agreed that site-specific implementation provisions should be developed to address the lake's unique conditions. This letter summarizes the regulatory approach that has been developed by the three parties, and requests that the RWQCB staff provide their written concurrence with this approach as part of the overall project review and approval process.

PROJECT DESCRIPTION

The Vista Grande Drainage Basin Improvement Project is being proposed by the City to pro-actively address instances of storm-related flooding in the Vista Grande Watershed Drainage Basin while providing the benefit of restoring the Lake Merced water surface elevation to desired levels. This approach builds upon the City's previous determination to focus on downstream improvements within the Vista Grande Watershed in advance of upstream projects within the basin. Of seventeen alternatives analyzed, the City has identified the

Lake Merced Alternative as its preferred alternative/proposed action, and will complete an environmental impact report (EIR) to evaluate the potential environmental impacts of the project prior to consideration for approval.

The project would consist of the following:

- Partial replacement of the existing Vista Grande Canal to incorporate a gross solid screening device, a treatment wetland, and diversion and discharge structures to route selected stormwater (and authorized non-storm water) flows from the Vista Grande Canal to South Lake Merced;
- Replacement of the existing Vista Grande Tunnel to expand its capacity; and
- Replacement of the existing outfall structure at Fort Funston

Please refer to the project description provided as **Attachment A** for a detailed description of the project. Daly City released a Notice of Preparation for the EIR in February 2013.

TWO-PART REGULATORY APPROACH OVERVIEW

Daly City, SFPUC, and the RWQCB have developed a two-part approach to address the 303(d) listing of Lake Merced. The first part is the development and implementation of a Lake Management Plan (LMP). The LMP would define the applicable best management practices (BMPs) that would be implemented to maintain and where feasible, improve water quality conditions in Lake Merced. However, with these BMPs alone, the existing water quality objectives may not always be met throughout the water column during seasonally stratified conditions that independently exist. Accordingly, new site-specific implementation provisions for the existing DO and pH water quality objectives (WQO) are proposed to be developed to address the unique conditions of Lake Merced.

Part 1 - Lake Management Plan

The City and SFPUC have agreed to develop and propose for approval a LMP that would maintain and, where feasible, improve the water quality of Lake Merced. The LMP will include goals and objectives, an operational plan for the proposed Vista Grande diversions, a water quality monitoring plan, evaluation of BMPs, and an implementation and adaptive management plan. The LMP will be developed in consultation with the RWQCB. The LMP will include pre- and post-project in-lake and Vista Grande Canal monitoring, and an adaptive management process regarding future monitoring and BMP implementation. Annual monitoring and management reporting to the RWQCB will be provided independently and separately from annual reporting provided in compliance with the Municipal Regional Stormwater NPDES Permit (MRP). The LMP, if approved by Daly City and the SFPUC, would be implemented pursuant to a legally binding operational agreement between Daly City and the SFPUC. The agreement would contain provisions requiring RWQCB notification and approval of specified changes to the LMP. A draft of these provisions will be provided to the RWQCB for review prior to finalizing the operational agreement.

The Draft LMP will be developed in the first half of 2013. Please refer to **Attachment B**, which provides an outline of the LMP.

Part 2 – Basin Plan Amendment

As the second part of the regulatory approach, the Basin Plan will be amended to incorporate site-specific implementation provisions for the DO and pH objectives. This is consistent with Basin Plan guidance (p. 3-2).

which states "*Compliance with water quality objectives may be prohibitively expensive or technically impossible in some cases. The Regional Board will consider modification of specific water quality objectives as long the discharger can demonstrate that the alternate objective will protect existing beneficial uses, is scientifically defensible, and is consistent with the state Antidegradation Policy. This exception clause properly indicates that the Regional Board will conservatively compare benefits and costs in these cases because of the difficulty in quantifying beneficial uses.*"

The unique conditions of Lake Merced that necessitate site-specific DO and pH implementation provisions include the following:

Polymictic. It is normal for deeper lakes and reservoirs to stratify in the summer, remain stratified until the fall turnover, and then remain mixed until the next summer stratification. During stratification, DO concentrations decrease in the lower unmixed layer (hypolimnion) due to the absence of aeration from the surface and from the oxygen demand by organic material decay in the sediments. Lake Merced also stratifies between late spring and early fall but is shallow enough for winds to periodically mix the lake (polymictic) from top to bottom for short periods of time before the stratification is re-established. These periodic mixing events are not sufficient to significantly increase the low dissolved oxygen levels (< 5 mg/L) that can be present within the hypolimnion during this seasonal stratification.

Terminal lake. Lake Merced was once a seasonal lagoon, but in the late 1800s, was developed into a reservoir to serve as a public water supply, and drainage from the increasingly urban watershed was diverted from the lake to the Pacific Ocean. The only outlet is an overflow to the Vista Grande Canal at a water surface elevation that has not been exceeded since the 1940s. Because the lake is not flushed with storm flows from the watershed, minerals have built up over time, increasing the alkalinity of the lake and thereby increasing the ambient baseline pH levels above those of typical lakes in the region. Therefore, normal diurnal pH increases due to algal photosynthesis in the upper photic zone can cause pH levels to increase above 8.5 solely due to the elevated alkalinity in this terminal lake.

Marine coastal influence. Lake Merced has relatively low temperatures for a lake of moderate depth at this latitude. This is due to the lake's close proximity to the Pacific Ocean. Prevailing winds bring cool air off the ocean as well as fog that blocks solar radiation, keeping the lake cooler than similar inland lakes.

Artificially maintained coldwater fishery. Lake Merced does not contain suitable spawning habitat nor is it connected to streams that provide suitable spawning habitat; therefore, it does not and cannot support a self-sustaining population of trout. However, the California Department of Fish and Wildlife (CDFW) has stocked the lake with rainbow trout for many decades in support of a popular put-and-take recreational fishery. The current DO and pH conditions in Lake Merced do not appear to be adversely affecting CDFW's ongoing stocking program.

Self-sustaining warmwater recreational fishery. Lake Merced maintains self-sustaining populations of native and non-native warm water fish species, including largemouth bass, carp, and catfish, which are targeted by anglers. The current DO and pH conditions in Lake Merced do not appear to be adversely affecting warm water habitat.

Emergency non potable water supply for San Francisco. The SFPUC has designated Lake Merced as an emergency non-potable water supply for the City of San Francisco to be used for firefighting or sanitation purposes if no other sources of water are available. Given that the Lake is designated as a potential water supply, SFPUC prohibits body contact recreation (e.g., swimming, wading) in the Lake.

The State's Impaired Waters Policy also recognizes that water quality standards may be inappropriately applied, making attainment impossible. In such cases, the Policy identifies that revision of the standards may be the best or only way to address the impairment. Daly City, SFPUC, and RWQCB have come to consensus that although implementation of the Lake Management Plan is expected to improve water quality, it will not independently resolve the impairment. Therefore, site-specific implementation provisions are required to make attainment of DO and pH objectives possible.

The findings made by the U.S. Environmental Protection Agency (USEPA) in its 2003 listing of Lake Merced for DO and pH impairment highlight the need to amend the water quality objectives (WQOs) for DO and pH, and/or establish a manner in which compliance with those WQOs is assessed to reflect site-specific conditions. In its findings, USEPA established "a low priority for this listing based on the considerations that no *specific beneficial use impairments have been associated with DO and pH problems in the Lake*, and that additional monitoring is warranted to verify these listings prior to developing TMDLs." USEPA concluded that "*absent Basin Plan language to the contrary, these standards apply at all water depths*" (*emphasis added*).

The proposed two-part regulatory approach is supported by the State Water Board's TMDL Guidance and the Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options (Resolution No. 2005-0050). This policy established that RWQCBs can formally recognize regulatory or non-regulatory actions of other entities as appropriate implementation programs that will result in the attainment of standards. The LMP, which if approved would be implemented by Daly City and SFPUC via an enforceable operational agreement, would serve as the appropriate implementation program, in combination with the site-specific implementation provisions modification

An annotated version of the Regulatory Decision Tree (**Attachment C**) from the State's Impaired Waters Policy graphically shows how the two-part regulatory process would proceed. If and when both the LMP becomes effective via the operational agreement and the site-specific DO and pH implementation provisions are adopted via a Basin Plan Amendment, the RWQCB could proceed with recommending to USEPA the delisting of Lake Merced (green arrow labeled Future Goal). Depending on the timing of the listing cycle, it could take several years for a delisting request to be approved. There may also be modifications needed to the SWB 2004 Listing Policy to accommodate the proposed DO and pH implementation provisions. If so, the RWQCB could potentially request that USEPA move Lake Merced to 303(d) Category 4b or 4c, clarifying that a TMDL is not required, while 303(d) list timing and/or Policy language issues are resolved to allow for full delisting.

Daly City, SFPUC, and RWQCB staff have agreed that the scope of the standards action will be to adopt site-specific objective implementation provisions for Lake Merced within the Basin Plan specifying how the existing DO and pH numerical objectives would be implemented and evaluated for 303(d) water quality assessment purposes. The State of Colorado has adopted standards and methodologies specific to lakes and reservoirs that take stratification into account. Colorado's approach to DO and pH assessment (summarized below) provides an example that can be applied as a starting point template and modified as necessary to reflect the site specific conditions unique to Lake Merced:

> <u>Dissolved Oxygen Assessment.</u> Assessment of dissolved oxygen within a profile of a lake or reservoir is accomplished by comparing the average of the measurements within the upper portion of the lake to the applicable standard. For lakes over 5 meters deep (such as Lake Merced), the upper portion is assessed as the average of all measurements from 0.5 meters to 2.0 meters. The lower portion of a lake is assessed by averaging the measurements from 1-3 meters above the bottom of the lake. In the lower portion of a lake, dissolved oxygen may be less than the applicable standard except where a site-specific standard has been adopted, or where adequate refuge is necessary for assessment of the temperature standard. Colorado's assessment methodology also provides for fall turnover of lakes and reservoirs, when seasonal stratification breaks down and low-DO water from the bottom of the lake rises and for a short period of time mixes with and lowers the DO of surface waters.
>
> <u>pH Assessment.</u> Assessment of the pH standard for a lake is accomplished by calculating the pH from the upper and lower portions of the lake. The 15th and 85th percentiles of the sample values from each portion are then compared to the minimum and maximum pH standard for the determination of attainment. Discrete samples from the upper and lower portions are evaluated separately because they represent different habitat regions in a stratified lake. When variations in pH are driven largely by biological processes within a lake, the risks of exceedance are generally associated with high pH in the upper portion (due to high rates of algal productivity) and low pH in the lower portion (due to high rates of decomposition).

A similar assessment methodology will be adapted for Lake Merced to address site-specific conditions. We do not propose changing the numeric DO and pH objectives presented in Chapter 3 of the Basin Plan, only how or where these standards are applied to Lake Merced. At the RWQCB's discretion, a footnote or other language may be added to the appropriate section(s) of Chapter 3 pointing to the Lake Merced Site-Specific Implementation Provisions language that would be added to the Chapter 4 Implementation Plan and/or Chapter 7 Water Quality Attainment Strategies Including TMDLs.

A draft scope and schedule for the Basin Plan Amendment process is provided as **Attachment D**. The scope and schedule is intended to assist in estimating the level of effort and duration of the Basin Plan Amendment process. Daly City will provide technical support to the RWQCB throughout the process. Daly City will also work with RWQCB to address its administrative costs to adequately staff this effort.

PROJECT PLANNING COORDINATION

The development of the LMP and Basin Plan Amendment will require consideration of, and coordination with, the following planning activities.

CEQA review

Daly City will begin preparation of an EIR to address the Vista Grande Project in early 2013. This EIR will also address the implementation of the LMP. Daly City understands that RWQCB will need to comply with the California Environmental Quality Act (CEQA) to address the means of compliance and environmental consequences of the Basin Plan Amendment. Daly City will work with RWQCB to ensure that the scope of the environmental analysis addresses the CEQA-equivalent requirements relative to the RWQCB's approval of the proposed Basin Plan Amendment to the extent practicable. As provided by CEQA, no approvals of the LMP, the Basin Plan Amendment, the operational agreement, and other discretionary projects decisions will be made prior to completion of the environmental analysis process.

Coverage under the Municipal Regional Permit

RWQCB staff has indicated that the proposed diversions of stormwater from the Vista Grande Canal to Lake Merced are covered under the existing MRP. Daly City understands that no additional NPDES permits are needed for operation of the proposed project. The City understands that additional discussion will need to be conducted with RWQCB and MRP co-permittees as the project progresses to determine the need, if any, to more specifically address the project via modifications to the MRP during the scheduled 2014 MRP reissuance process. Daly City will apply for and obtain a Clean Water Act Section 404 Permit from the US Army Corps of Engineers and associated Section 401 Water Quality Certification from RWQCB for the construction of the proposed facilities.

Operational Agreement

Upon completion of the CEQA process, Daly City and SFPUC will consider the approval of a legally binding operational agreement to address development of permanent Daly City facilities on CCSF lands, operation of the project, stormwater diversion threshold criteria, wetlands flow management, lake level management, and implementation of the LMP. The agreement would include commitments and conditions describing how the treatment wetlands would be constructed and managed to comply with RWQCB Resolution No. 94-102 "*Policy on the Use of Constructed Wetlands for Urban Runoff Pollution Control.*" The agreement would contain provisions requiring RWQCB notification of specified changes to the LMP. Daly City and SFPUC are currently working on an outline of the operational agreement, and will provide it to the RWQCB for review.

Timeline of Permits and Approvals

Daly City anticipates completing the CEQA process for the proposed project in mid-2014, assuming the full cooperation of state and federal agencies. During completion of the CEQA process, Daly City will begin to obtain all necessary permits and approvals for the project, including the Section 401 Water Quality Certification required from the RWQCB. The Section 401 Water Quality Certification is the only permit/approval believed to be necessary from RWQCB to allow construction and operation of the proposed facilities. The Basin Plan Amendment would require approval by the RWQCB followed by approval by the State Water Resources Control Board, Office of Administrative Law, and USEPA. Please refer to the draft scope and schedule provided in Attachment D for additional details on the sequence of major activities.

CONCLUSION

Daly City respectfully requests the RWQCB staff's written concurrence with the regulatory process as outlined above as the initial step in the overall project approval process. The City understands that the

RWQCB will be providing comments and/or conditions on the project as part of the 401 Certification and CEQA processes. Following completion of the 401 Certification and CEQA processes, the City may request a second letter from RWQCB staff indicating approval of the project conditioned on compliance with the terms and conditions contained in the LMP, operational agreement, 401 certification, and CEQA monitoring and mitigations

Sincerely,

Patricia E. Martel
City Manager

L13-039

cc. Steve Ritchie, SFPUC

PROJECT DESCRIPTION

Daly City Vista Grande Drainage Basin Improvement Project

Introduction

The City of Daly City (City) is proposing the Vista Grande Drainage Basin Improvements project to address storm related flooding in the Vista Grande Watershed Drainage Basin while providing the benefit of restoring the level of Lake Merced. The Vista Grande stormwater system drains the northwestern portion of the City and an unincorporated portion of San Mateo County – areas originally within the watershed of Lake Merced. In the 1890s, the Vista Grande Canal and Tunnel were built to divert stormwater away from the lake to an outfall at the Pacific Ocean, below what is now Fort Funston. The existing canal and tunnel do not have adequate hydraulic capacity to convey peak storm flows, and during storm events, flooding periodically occurs in adjacent low lying residential areas and along John Muir Drive. The proposed project would alleviate flooding and protect the ocean outfall from ongoing coastal erosion while reconnecting a significant portion of the Lake Merced Watershed.

Background

The City evaluated seventeen alternatives for managing stormwater in the Vista Grande Drainage Basin. The alternatives included various combinations of facilities including different tunnel alignments and capacities, storm water detention structures and groundwater recharge facilities. Alternatives were evaluated based on their potential for reducing flooding, operational viability, public impacts, environmental benefits and constructability. The Lake Merced Alternative emerged as the preferred alternative, based on its "green infrastructure" approach of using stormwater to restore the level of Lake Merced, which declined in the late-80s and early-90s and has not fully recovered. The City has worked closely with the San Francisco Public Utilities Commission (SFPUC) and the San Francisco Bay Regional Water Quality Control Board (RWQCB) in the development of this project. The City intends to prepare an Environmental Impact Report (EIR) for the proposed project in compliance with the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA). The Lake Merced Alternative, described below, will be considered the proposed project in the EIR. Other alternatives will be evaluated as required by CEQA and NEPA.

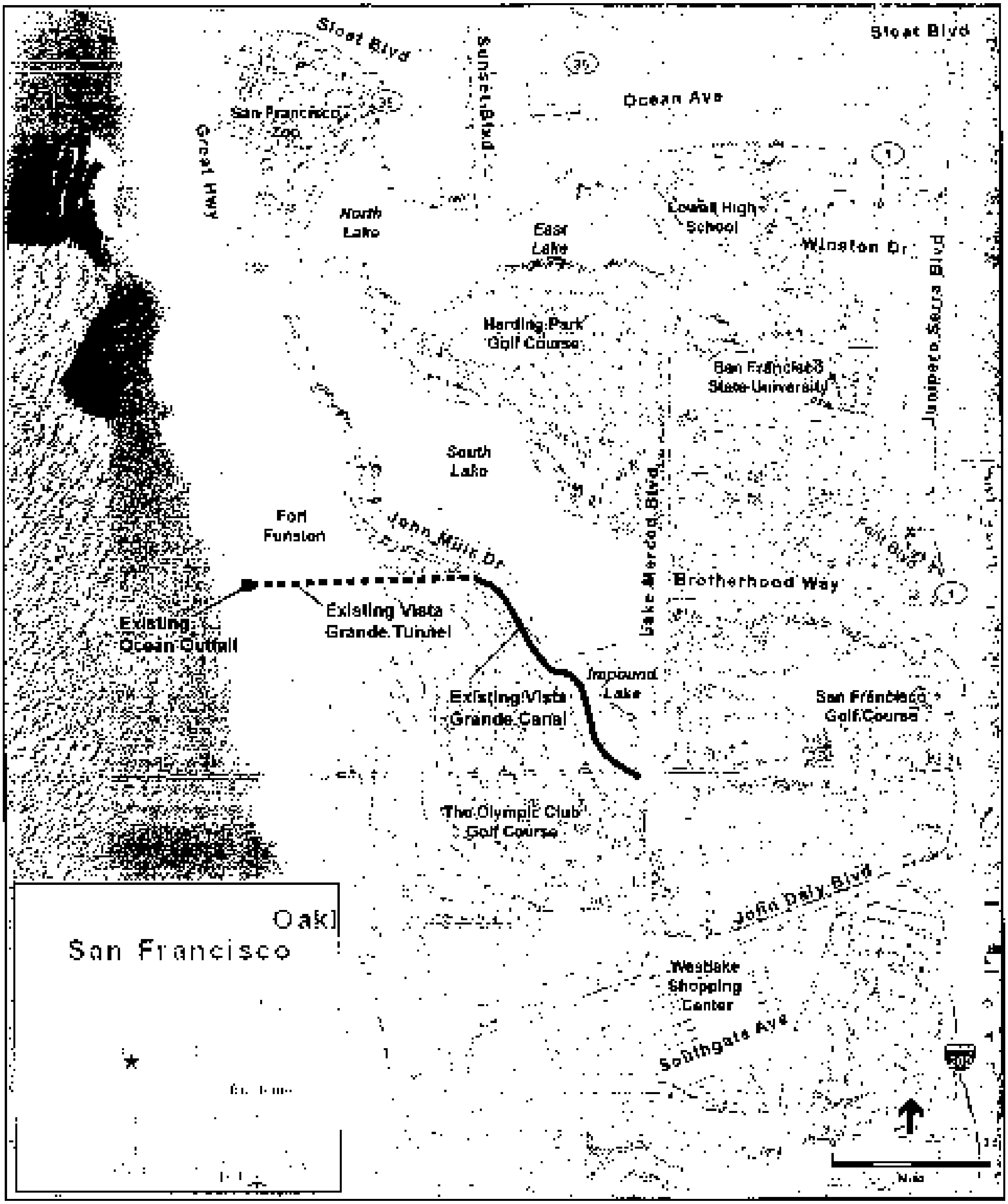
Project Location

The Vista Grande watershed area is located in the city of Daly City and unincorporated Broadmoor Village, in northwestern San Mateo County. This watershed is approximately 2.5 square miles in area and is bordered by San Francisco County to the north, Colma Creek watershed to the south and east, and the Pacific Ocean on the west. The watershed is drained through the Vista Grande Canal and Tunnel which are located in the City and County of San Francisco, adjacent to John Muir Drive and the southwestern shoreline of Lake Merced. The tunnel outfall is located at the Pacific Ocean at Fort Funston, which is managed by the National Park Service (NPS) as part of the Golden Gate National Recreation Area (GGNRA). The Project location is shown in **Figure 1**.

Project Objectives

The City has identified the following objectives for the proposed project:

Flood Protection	• Improve the lower Vista Grande Drainage Basin to safely route stormwater to reduce public hazard and minimize property damage, business interruption and public inconvenience • Reduce the number of uncontrolled overflows from the Vista Grande canal into Lake Merced
Water Resource Management	• Implement stormwater best management practices to facilitate the beneficial re-use of stormwater • Provide a sustainable source of stormwater to facilitate the management of the Lake Merced water surface elevation • Increase groundwater recharge • Protect and, where feasible, improve South Lake Merced water quality • Manage Lake Merced overflow capacity to minimize environmental and property damage associated with large storms and high lake levels
Environmental	• Improve the recreation access along the beach below Fort Funston • Reduce litter transfer and deposition on the beach below Fort Funston • Reduce the project footprint and minimize construction-related disruptions of surrounding recreational uses and vehicle and pedestrian traffic by maximizing use of existing rights-of-way, easements, and infrastructure • Provide environmental benefits by providing, among other benefits, water quality treatment and wildlife habitat • Accommodate sea level rise and coastal erosion • Improve the aesthetic, educational and recreational benefits of stormwater facilities
Economic	• Protect residential property values by improving flood protection • Reduce construction cost, time, and materials by maximizing use of existing rights-of-way, easements, and infrastructure alignments • Reduce stormwater management life-cycle costs (capital, operating and maintenance) • Reduce waste water effluent management life-cycle costs (capital, operating and maintenance) • Reduce coastal litter cleanup and disposal costs • Minimize property damage and business interruption by improving flood protection



SOURCE:

Vista Grande Drainage Basin Improvement Project. 207036.01

Figure 1
Project Location

Proposed Project Components

The project would consist of the following:

- Improvements within the Vista Grande watershed collection system upstream of the Vista Grande Canal;
- Partial replacement of the existing Vista Grande Canal to incorporate a gross solid screening device, a treatment wetland, and diversion and discharge structures to route some stormwater (and authorized non-storm water) flows from the Vista Grande Canal to South Lake Merced;
- Replacement of the existing Vista Grande Tunnel to expand its capacity; and
- Replacement of the existing outfall structure at Fort Funston.

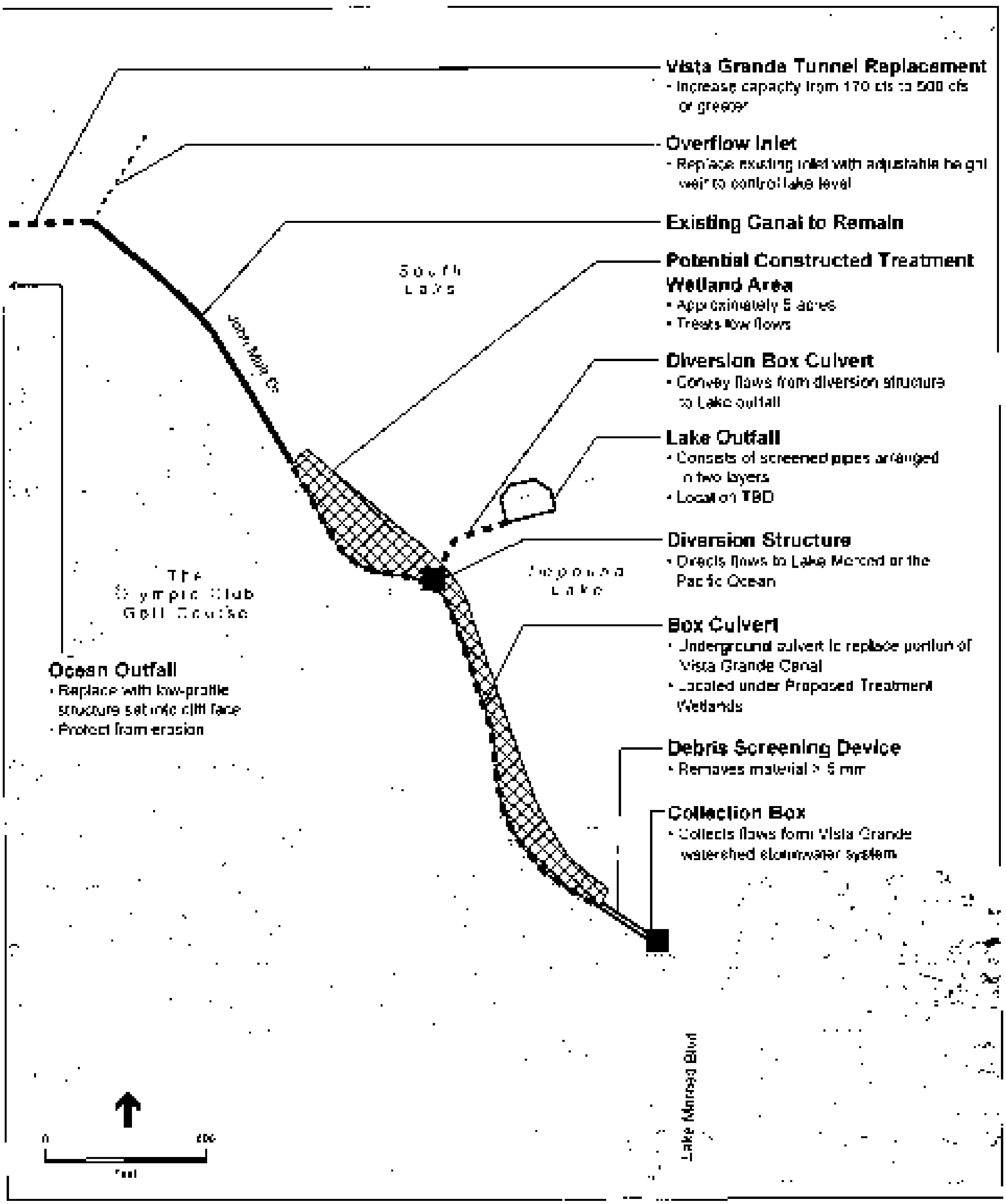
These components are described below, and locations are shown in **Figure 2**.

Vista Grande Canal Improvements and Diversion to Lake Merced

The existing Vista Grande Canal is a 3,600-foot-long brick-lined trapezoidal channel with a flow capacity of 500 cubic feet per second (cfs). Under the proposed project, a portion of the canal would be replaced with several new facilities to improve storm water quality and conveyance capacity. A collection box, debris screening device, box culvert, and diversion structure would replace the upstream portion of the canal. A treatment wetland would be developed over the box culvert in an area between John Muir Drive and the southern edge of the canal. From the diversion structure, a box culvert would be developed under John Muir Drive and a screened outfall structure constructed at the edge of South Lake. These components are described below.

Collection Box and Debris Screening Device

A collection box would replace the headworks of the existing Vista Grande Canal to collect flows from the contributing storm drains. An approximately 275-foot long linear radial debris screening device would be installed downstream of the collection box. Stormwater would enter the box culvert structure through several cylindrical casings and exit through louvers perforated in the casings, trapping all debris greater than 5 mm within the casings. Debris would be removed from the well casings with vacuum trucks on a scheduled basis.



SOURCE: ESA

Vista Grande Drainage Basin Improvement Project 207036.01
Figure 2
Project Components

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Box Culvert

Directly downstream of the debris screening structure, a reinforced concrete box culvert would replace approximately 1,500 feet of the existing canal. The proposed box culvert would run underneath the proposed treatment wetland described below.

Constructed Treatment Wetland

A constructed treatment wetland would be developed along John Muir Drive, a portion of which would overly the box culvert. The wetland would treat low flows from the watershed (also referred to as base flows), which consist of authorized non-stormwater flows (such as irrigation runoff that are present in the canal all year). The water would be pumped from the box culvert to the wetland. Water would flow via gravity through a cascading series of hydraulically connected cells. Portions of each cell would be planted with emergent reeds such as cattails or bulrush, which would provide water quality improvement by intercepting and settling out suspended particulates and providing attachment surfaces for beneficial bacteria. Open-water portions of each cell would allow wind mixing of the water column and would provide habitat for mosquitofish to reduce mosquito breeding in the wetlands. After passing through the wetland, the treated water would flow by gravity through the diversion structure to the outfall at South Lake. During periods of very low or no flow, a recirculating pump would draw water from South Lake and replenish the wetland.

Diversion Structure

A semi-automated hydraulic diversion structure would be constructed directly downstream of the box culvert and treatment wetlands to direct flows to either the Pacific Ocean or South Lake. The diversion structure would be comprised of a box culvert with one set of control gates that would direct flows to the existing Vista Grande Canal and ocean, and one set of control gates that would direct flows to a diversion box culvert and Lake Merced. The diversion of flows would be conducted as described in the System Operation section below.

Diversion Box Culvert and Lake Outfall Structure

Flows that are directed into South Lake would be conveyed into the lake via a box culvert constructed under John Muir Drive to an outfall at the southwestern edge of South Lake or northwestern portion of Impound Lake. The water would flow through the submerged outfall structure into the lake. The specific location of the outfall structure will be determined based on further engineering and environmental review. Depending on the final location, the outfall structure and/or the associated box culvert may be routed beneath the SFPUC's existing transport tunnel that crosses between Impound Lake and South Lake.

Lake Merced Overflow

An existing Lake Merced overflow structure consists of a brick and masonry riser and tunnel that connects South Lake with the Vista Grande Canal. Under the proposed project, a portion of the existing Lake Merced overflow would be replaced with an adjustable-height weir that would be used to control the lake level and allow water to be diverted back into the Vista Grande Canal. As described in the System Operation section below, three operational lake level scenarios will be evaluated with overflow elevations at El. 7.5, 8.5, or 9.5 (San Francisco City Datum). At water surface elevations below approximately 8.5 feet, pumping would be required to lift the water to the elevation of the canal.

Vista Grande Tunnel Replacement

The existing Vista Grande Tunnel constructed in 1896 has a hydraulic capacity of 170 cfs. The Tunnel would be enlarged to increase its capacity to 500 cfs or greater and to extend its operating life. Alternatively, a new tunnel could be bored adjacent to and parallel with the existing tunnel. Under either option, the new tunnel would have a concrete lining and would incorporate a wholly contained section of a 30-inch diameter pipeline to transport treated effluent from the Daly City Wastewater Treatment Plant to the ocean outfall.

Ocean Outfall

Daly City's existing outfall structure is located on the beach below Fort Funston. The outfall structure discharges the Vista Grande Watershed stormwater and also connects an existing 30-inch effluent force main from the Daly City Wastewater Treatment Plant with a subsurface and sub-marine outfall pipeline. The outfall structure, a segment of the Vista Grande Tunnel, and the force main segment are fully exposed to the surf and waves which have caused significant damage to the structure and contributed to the ongoing erosion of the cliff face.

The proposed project would reconfigure these structures to provide protection from the surf and waves. The existing Daly City outfall structure would be removed and replaced with a low-profile outfall structure set into the existing cliff face to reduce future erosion (**Figure 3**). The existing 30-inch force main would also be removed and replaced with a similar configuration set back into the cliff face. The existing submarine outfall pipeline and diffuser would be renovated to protect it from erosion and extend its operating life.

View of Existing Outfall Structure

Simulation of Proposed Outfall Structure

Figure 3
Existing and Proposed Ocean Outfall Structure

Project Construction

Improvements to the Vista Grande Canal and the facilities associated with the diversion to Lake Merced would be constructed from staging areas located adjacent to the construction areas. Construction of the canal improvements, diversion structure, and treatment wetland would require site clearing and removal of trees in the area bounded by Lake Merced Boulevard, John Muir Drive, and the southern edge of the canal. Some utility relocations will also be needed.

The proposed Vista Grande Tunnel would be constructed using a tunnel shield or a soft ground tunnel boring machine. The machine would be launched from a construction shaft located at Fort Funston, or from a staging area adjacent to the Vista Grande Canal off John Muir Drive. The City has an existing 100-foot right of way across Fort Funston providing perpetual use for sewerage, drainage and lake protection purposes. The construction shaft would be approximately 40 feet in diameter. A crane would be positioned near the shaft edge to hoist personnel, materials, and equipment between the tunnel and the surface. The main construction staging area would be located adjacent to the shaft and most construction activities associated with tunnel construction would take place in this area. The desired construction shaft staging area acreage is about four acres.

Construction access to the new Daly City Ocean Outfall structure on the beach below Fort Funston would be provided either through the construction shaft or from a temporary access road constructed between Fort Funston and the beach.

Operation

Lake Level Management

The proposed project will divert some stormwater and authorized non-stormwater flows to South Lake to aid the SFPUC in operating Lake Merced within desired water levels. The water level of Lake Merced has fluctuated historically from Elevation (El.) 13 feet (San Francisco City Datum) in the 1940s to a low of El. -3.2 feet in 1993. Since then, the water surface elevation (WSE) of Lake Merced has risen due to increases in average rainfall and water additions by the SFPUC (SFPUC, 2011). From 2006 to 2010, the lake level ranged from El. 4.8 feet to El. 6.9 feet with an average of approximately El. 5.8 feet (City Datum). SFPUC has identified a goal of restoring historic water levels in the lake to serve beneficial uses and provide a reliable emergency water supply for firefighting and sanitation purposes.(SFPUC, 2011). The SFPUC has identified a preliminary target range of El. 5.5 to El. 9.5 feet (City Datum). The EIR will evaluate three lake level operational scenarios within this preliminary target range, and based on the analysis presented in the EIR, the SFPUC will identify the preferred operational scenario under which the project will be managed.

The three operational scenarios are identified by the target maximum WSE– 7.5, 8.5, and 9.5 feet (see **Figure 4**). This is the elevation at which the lake overflow weir would be set under each scenario. After winter rains taper off, about 1.5 feet of water is lost each year, primarily due to evaporation. Thus, for each scenario there is a corresponding target normal minimum WSE. The term normal is used to refer to normal and wet year conditions. Under dry year and multiple dry year conditions, it is assumed that WSE of Lake Merced would fall below the target normal range. During a storm event, the lake's WSE may rise above the target maximum WSE, as the flow of stormwater being diverted into the lake exceeds the capacity of the overflow outlet, thus providing short-term water storage for flood events.

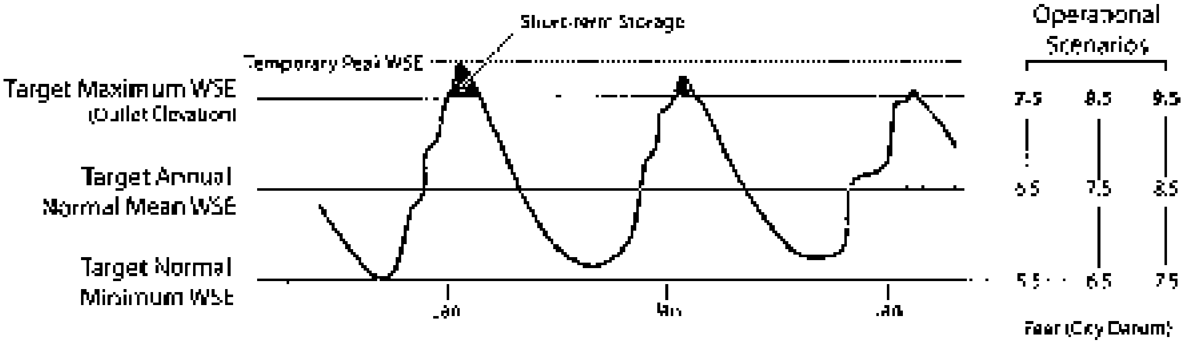


Figure 4
Lake Level Operational Scenarios

Operating Modes

In order to maintain lake levels within target WSEs and to ensure protection of Beneficial Uses within Lake Merced, the proposed operating model includes provisions for several operating modes dependant on flow and storm water quality. Three principal operating modes are described below and shown in **Figure 5**.

1. **Screened low-flows in the Canal can be routed through a wetlands system before being released to Lake Merced.** Screened dry weather flows (authorized non-stormwater) and low stormwater flows can be routed through a wetlands natural treatment system. These flows would help to maintain overall lake level and sustain the proposed treatment wetlands throughout the year.

2. **Screened higher canal flows satisfying a storm water quantity or quality criteria can be routed into Lake Merced.** Winter storm water flows exceeding the capacity of the wetlands natural treatment system can be routed to either Lake Merced or the Pacific Ocean.

3. **Screened higher canal flows can be routed to the Pacific Ocean.** Screened storm water flows exceeding the capacity of the wetlands natural treatment system but not satisfying the storm water quantity or quality criterion can be routed to the Pacific Ocean via the canal, tunnel, and outfall structure.

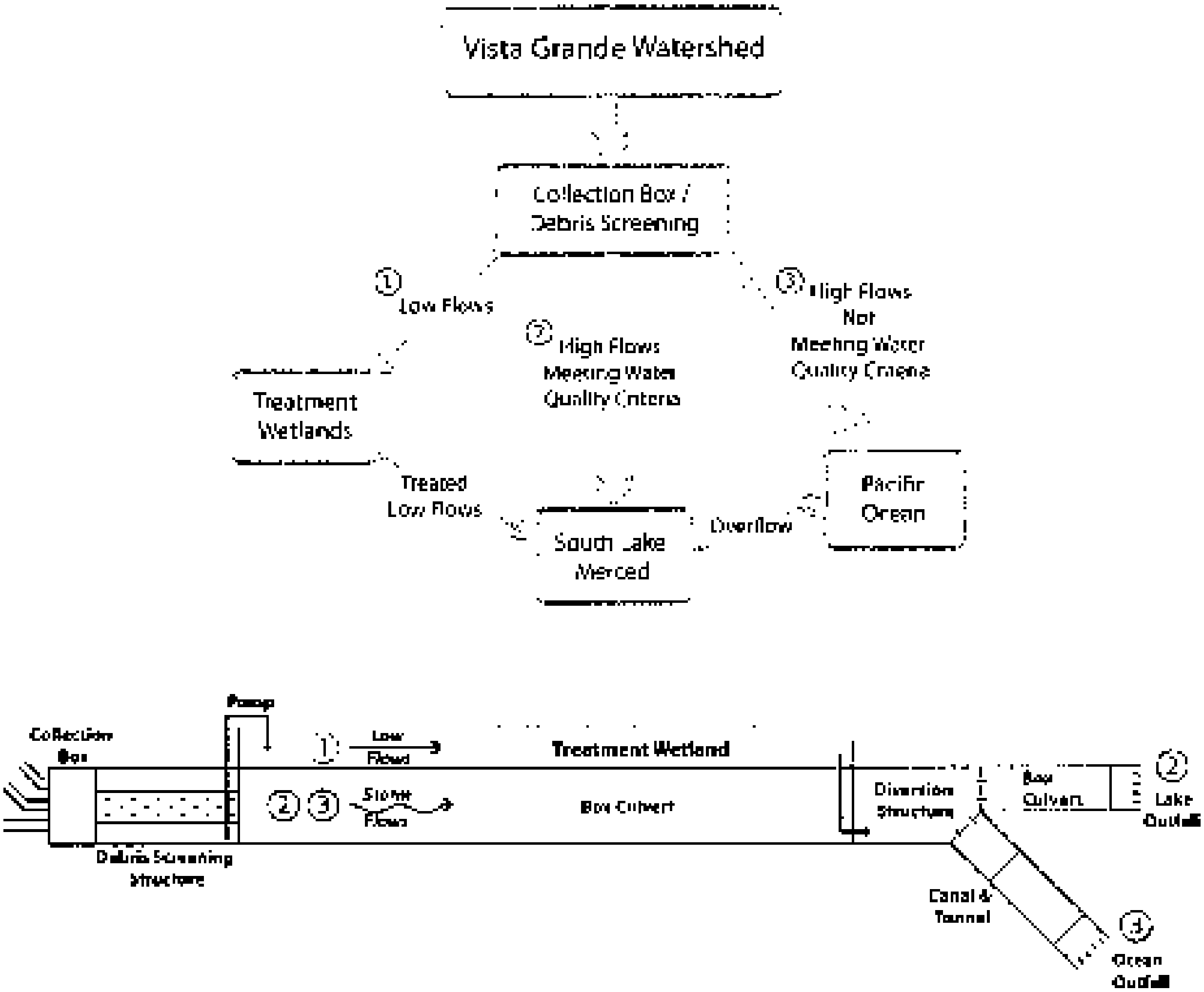


Figure 5
Flow Diagram

Lake Management Plan

The City and SFPUC have agreed to develop a Lake Management Plan (LMP) to maintain and where feasible improve the water quality of Lake Merced. The LMP will include an operational plan for the proposed Vista Grande diversions, a water quality monitoring plan, and best management practices that would be implemented by the City and SFPUC. The LMP will be developed in consultation with the RWQCB with respect to project review under the National Pollution Discharge Elimination System (NPDES).

Regulatory Requirements, Permits and Approvals

Private, local, state, and federal entities own the lands needed to construct, operate, and maintain the proposed project. The City would need to consult with relevant resource agencies and follow prescribed environmental review processes to evaluate project environmental effects and obtain construction permits for proposed components or improvements. The following table summarizes the agencies with regulatory oversight, the governing regulation and the likely permits and approvals that would be necessary.

Agency	Governing Regulation	Potential Requirements
City of Daly City Lead Agency, (California)	California Environmental Quality Act (CEQA)	CEQA Compliance (EIR)
U.S. National Park Service - Golden Gate National Recreation Area, Lead Agency (Federal)	National Environmental Policy Act (NEPA)	NEPA Compliance, Special Use Permit; Right-of-Way Permit
California Coastal Commission	California Coastal Act; Coastal Zone Management Act	Coastal Development Permit; Local Coastal Plan compliance; Public Works Plan; Federal Consistency Determination
U.S. Army Corps of Engineers	Clean Water Act	Section 404 Authorization
U.S. Fish and Wildlife Service	Endangered Species Act	Section 7 Consultation
National Oceanic and Atmospheric Association	Endangered Species Act and Magnuson-Stevens Essential Fish Habitat	Section 7 Consultation
State Water Resources Control Board	Clean Water Act	General Construction Permit
San Francisco Bay Regional Water Quality Control Board	Clean Water Act	NPDES Stormwater coverage, Section 401 Water Quality Certification; Section 402 Policy on the Use of Constructed Wetlands for Urban Runoff (No. 94-201)
California Department of Fish and Game	Fish and Game Code Section 1602	Lakebed Alteration Agreement
California Office of Historic Preservation	National Historic Preservation Act	Section 106 Consultation

References

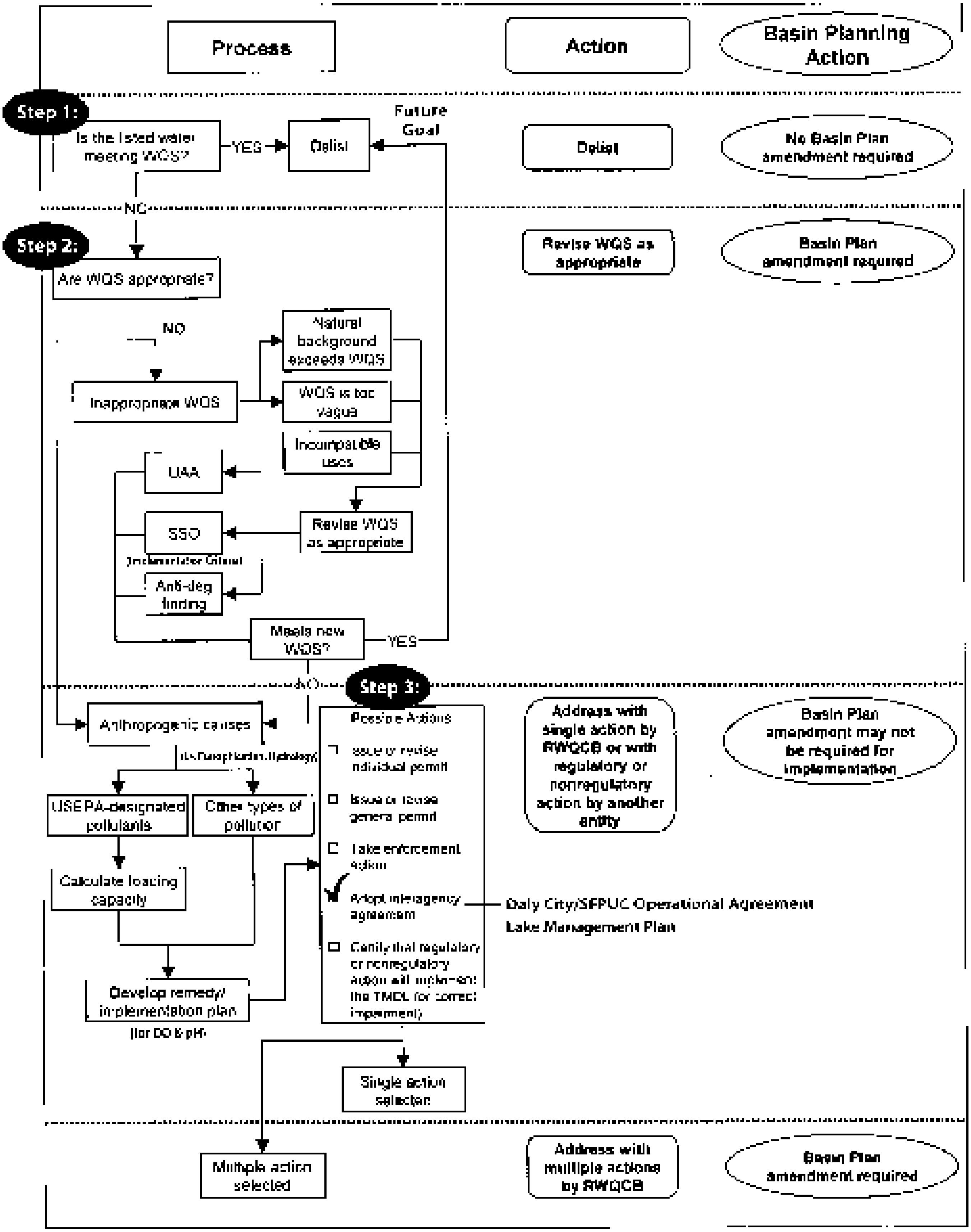
San Francisco Public Utilities Commission (SFPUC), *Lake Merced Watershed Report*. January, 2011.

Vista Grande Drainage Basin Improvement Project March 11, 2012
South Lake Merced Alternative
Lake Management Plan Outline

1. Plan Goals and Objectives
   - Restore and maintain water surface elevation of Lake Merced
   - Maintain/improve water quality in Lake Merced
   - Maintain /improve aquatic habitat
2. Vista Grande Operational Plan
   - Lake level management
     - Normal operational range, overflow elevation
   - Diversion operation
     - Diversion criteria for storm flows (dry weather interlude duration, volume)
     - Treatment criteria for canal base flows
     - Facility operation and maintenance
3. Implementation and Adaptive Management Plan
   - BMPs
     - Schedule/Phasing
     - BMP assessment & adaptive management
   - Lake Management Actions (DO and pH maintenance)
     - Implementation Criteria
     - Management action assessment & adaptation
   - Reporting schedule
   - Implementation plan assessment & adaptation
4. Water Quality Monitoring Plan
   - Summary of existing water quality
   - Water quality objectives and goals
   - List of constituents and parameters to be monitored
   - Temperature, DO and pH monitoring
   - Sampling program
     - Lake Merced
     - Vista Grande Canal
   - Reporting schedule
   - Monitoring plan assessment & adaptation

Appendix A: BMP & Lake Management Actions Evaluation

Attachment C



Source: Adapted from SWRCB, 2005

SWB Regulatory Decision Tree: Process for Addressing Impaired Waters - Adapted for Lake Merced

Attachment D

Regulatory Process Scope & Schedule
Vista Grande Drainage Basin Improvement Project

2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Vista Grande Project Environmental Review

- Notice of Preparation (NOP) and Notice of Intent (NOI) Issued
- Preparation of joint CEQA Project Description; Scoping Meetings
- Preparation of Administrative Draft EIR/EIS
- Preparation of Public Draft EIR/EIS; Prepare Permit applications (USACE and RWQCB 401, USFWS Section 7, CDFW Lake/Streambed Alteration Agreement, CCC Coastal Development Permit, etc.)
- Public Review and Comment Period

Lake Management Plan

Develop Draft LMP:

- Develop Goals and Objectives – Identify broad project goals and the specific physical attributes (objectives) that can be measured, monitored, and used in an evaluation of enhancement actions
- Vista Grande Operational Plan – Define the annual operation range, stormwater diversion volume, treatment criteria, and facility operation and maintenance
- Feasibility Review – Assess the feasibility of source control and lake management actions including the review of available technology, engineering and site constraints, permitting and phasing considerations, etc.
- Water Quality Evaluation – Evaluate the selected range of management actions to determine the ability to meet water quality goals, addressing influences on DO and pH levels and general water quality benefits
- Fisheries Evaluation – Evaluate and select management options to address potential effects to fish habitat
- Implementation and Adaptive Management Plan – Identify: 1) BMPs and lake management actions to maintain/improve water quality; 2) an implementation schedule; and 3) assessment and adaptive management
- Water Quality Monitoring Plan – Identify list of constituents and parameters to be monitored, locations, depths, frequency, and methodology for monitoring; and a reporting and monitoring plan assessment schedule

Basin Plan Amendment

Project Analysis – Complete Phases 1-5 of California Impaired Water Process (see Table 3-1, pg. 3-5 of A Process for Addressing Impaired Waters in California, SWRCB, 2005)

- Phase 1 – Definition of project, potential constituents, and location
- Phase 2 – Compile existing information, identify data needs, develop study plans and engage stakeholders
- Phase 3 – Data collection and analysis
- Phase 4 – Project report(s) with data and analysis findings. May include impairment assessment, source and loading analyses, implementation alternatives
- Phase 5 – Develop recommendations for regulatory action; complete required filings

NOTE: This information will be provided by the Lake Management Plan and Water Quality Assessment

SFPUC

- LMP: Review and provide comments on goals and objectives
- ENV: Review and provide comments on draft CEQA Project Description; LMP: Provide input on feasibility analysis and cost estimates
- LMP: Provide input on operational plan, evaluation, management and monitoring plan
- LMP: Review and provide comments on Draft LMP
- ENV: Review and provide comments on Admin Draft EIR/EIS; LMP: Review Final LMP
- ENV: Review and provide comments on Screencheck Draft EIR/EIS

RWB

- ENV: Review and provide comments on NOP; LMP: Review and provide comments on goals and objectives; BPA: Start Administrative Record
- LMP: Provide input on operational plan, evaluation, management and monitoring plan
- LMP: Review and provide comments on Draft LMP; BPA: CEQA Scoping for Basin Plan Amendment
- ENV: Review and provide comments on Draft EIR/EIS

NPS

- ENV: Issue Notice of Intent (NOI) in Federal Register
- ENV: Review Project Description & Scope of EIS; ENV: Hold scoping meeting(s)
- ENV: Review and provide comments on Admin Draft EIR/EIS
- ENV: Review and provide comments on Screencheck Draft EIR/EIS; ENV: Consultation with California Office of Historic Preservation – compliance with the National Historic Preservation Act (NHPA)

March 13, 2013

Attachment D

Regulatory Process Scope & Schedule
Vista Grande Drainage Basin Improvement Project

2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Vista Grande Project Environmental Review	Preparation of Administrative Draft Responses to Comments (RTC) and Final EIS/EIR (Jan–Mar) Preparation of Public RTC/Final EIR/EIS; Develop Mitigation Monitoring and Reporting Plan (Apr–May) CEQA Findings and NEPA/EIS Approval; Preparation of Record of Decision (NPS) (Jun) Permitting: Consultation with permitting agencies (USACE, RWQCB, USFWS, CDFW, CCC, etc.) (Jan–Jul) Obtain permits: USACE 404, RWQCB 401, USFWS Section 7, CDFW Lake and Streambed Alteration Agreement, CCC Coastal Development Permit, etc. Dependent on completion of CEQA/NEPA (Aug) Final Engineering and Design (Sep–Dec)
Lake Management Plan	Develop Final LMP: Address comments on Draft LMP (Jan–Jun) Daly City and SFPUC sign Operational Agreement. Dependent on completion of CEQA (Aug) Commence Pre-Project Monitoring (as determined by LMP) (Sep–Dec)
Basin Plan Amendment	Preparation of internal Draft Regional Board Agenda Item Package (Staff Report) (Jan–Jun) NOTE: Endangered species consultation will be undertaken for the Vista Grande project. Consultation will occur with RWB to address BPA. Regional Board Attorney review of Draft Staff Report (Jul) State Plan Unit/Legal review of Draft Staff Report (Jul–Aug) Scientific Scope Peer Review of Draft Staff Report (Aug–Oct) Response to reviewer comments and internal Draft Agenda Item Package/Staff Report review (Nov–Dec) NOTE: Technical Support provided by Daly City
SFPUC	ENV: Review and provide comments on Draft Responses to Comments (RTC) and Final EIS/EIR (Mar–Apr) LMP: Sign Operational Agreement. Dependent on completion of CEQA (Aug)
RWB	BPA: Prepare Draft Staff Report; LMP: Review RWQCB notification provisions of Draft DC/SFPUC Operational Agreement (Jan–Jun) BPA: Internal RWB review of Draft Agenda Item Package/Staff Report; ENV: Issue 401 Water Quality Certification (Jul–Oct) BPA: Response to reviewer comments and internal package review (Nov–Dec)
NPS	ENV: Review and provide comments on Draft Responses to Comments (RTC) and Final EIS/EIR (Mar–Apr) ENV: Complete consultation with California Office of Historic Preservation; ENV: Prepare and sign Record of Decision (NPS) (Jul) ENV: Approve special use permit and/or ROW. Dependent on completion of NEPA (Aug)

March 15, 2013

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Regulatory Process Scope & Schedule
Vista Grande Drainage Basin Improvement Project

2015	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vista Grande Project Environmental Review	Pre-Construction Activities					Construction (through 2017) ⇨						
Lake Management Plan	Pre-Project Monitoring (as determined by LMP)											
Basin Plan Amendment	Preparation and distribution of Public Draft Agenda Item Package/Staff Report	Public review and comment period Draft Agenda Item Package/Staff Report		Revision of Agenda Item Package/Staff Report based on comments received. Preparation and distribution of Final Agenda Item Package/Staff Report to public.		Presentation of proposed Amendment to Board. Regional Board Adopts Amendment	State Board review of Administrative Record and Hearing for regionally adopted Basin Plan Amendment				OAL Process	EPA Approval ⇨
SFPUC												
RWB	BPA: Revise and distribute Staff Report. Dependent on completion of CEQA					BPA: Present BPA to board for adoption. Submit MSC release to ED and obtain signature, finalize Administrative Record.	BPA: Submit Admin Record to SB and OAL. SWQB: Prepare TMDL Implementation Package					BPA: Pay CDFW fee, file NOD, revise Basin Plan ⇨
NPS												

March 13, 2015

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APPENDIX B

2011-2012 Wet and Dry Season Monitoring Plans and Results

Contents:

Final 2011 Dry Season Monitoring Plan

Final 2011-2012 Wet Season Monitoring Plan

Sampled storm hydrographs showing sample aliquots corresponding to volumetric sample pacing

Detailed results of dry and wet season water quality monitoring for Project

Lake Merced Pilot Stormwater Enhancement Project Summary

Preliminary Water Quality Screening Results for the Lake Merced Pilot Stormwater Enhancement Project: 2003/04 – 2008/09 Wet Weather Seasons

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Final 2011 Dry Season Water Quality Monitoring Plan – Vista Grande Drainage Basin Improvement Project

September 16, 2011

1.0 INTRODUCTION

The City of Daly City has prepared this water quality monitoring plan in support of the Lake Merced Alternative of the Vista Grande Drainage Basin Improvement Project (Project). Lake Merced is the largest freshwater lake located within the City and County of San Francisco (CCSF) and it is operated and maintained by the San Francisco Public Utilities Commission (SFPUC). The northwestern area of Daly City and unincorporated portions of San Mateo County drain into the Vista Grande portion of the City's stormwater collection system. The underground collection system conveys the storm flows to the Vista Grande Canal and then into the Vista Grande Tunnel, which discharges through the Daly City outfall structure into the Pacific Ocean at the beach below Fort Funston. Historically wet weather flows in excess of the capacity of the Canal and the Tunnel have occasionally resulted in local flooding and overflows across John Muir Drive into Lake Merced, causing property damage, bank erosion, traffic nuisances, and public safety issues (RMC, 2006).

The Lake Merced Alternative (the Project) would route a portion of wet season storm flows from the Vista Grande Canal directly to South Lake Merced (South Lake) and a smaller portion of wet season storm flows from the Canal through a proposed treatment wetland to South Lake. In addition, dry season base flow (or runoff) would be routed through the proposed treatment wetland to South Lake.

This monitoring plan has been developed based on a review of water quality monitoring data previously collected by the SFPUC, the City of Daly City and the City and County of San Francisco (Kennedy Jenks, 2010). The intent of the proposed monitoring plan is to provide specific water quality information needed to inform project design and environmental analysis for CEQA and NEPA[1] documentation; and to facilitate project review by the San Francisco Bay Regional Water Quality Control Board (RWQCB). To that effect, the monitoring data will help quantify dry season flow and establish baseline water quality within the Canal and expand on the existing water quality data set for South Lake. The data will be collected from the Canal and South Lake at the same time to develop a comparable data set for the Project.

2.0 PROPOSED MONITORING PLAN

Dry season monitoring of flow and water quality will be conducted in the Canal from approximately August 15 to October 31, 2011. Water quality in South Lake will be monitored during the same period to assess the baseline conditions of the receiving waters for the project and to inform conceptual design of

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[1] California Environmental Quality Act, National Environmental Policy Act

the treatment wetlands. For the purpose of this plan, low flows are defined as flows that occur in the Vista Grande Canal during the summer and fall (June 1-October 31) and are primarily associated with exempted and conditionally exempted non-stormwater discharges (e.g., car washing, lawn watering, and landscape irrigation) as described in Provision C.15 of the Municipal Regional Stormwater NPDES permit. Typical dry season base flow within the Vista Grande Canal is estimated to average between 0.1 and 0.4 million gallons per day (mgd) or approximately 0.2 to 0.6 cubic feet per second (cfs). Constructed wetlands must have a source of water throughout the year so that the wetland plants and other organisms within the wetland ecosystem can be maintained. However, dry season flow data is limited and has not yet been accurately quantified and assessed for water quality.

The objectives of the dry season monitoring are to:

- Provide flow and water quality data to characterize baseline conditions in the Vista Grande Canal during summer months for the Project;
- Further establish the water quality of the receiving waters (South Lake) to adequately characterize baseline receiving water quality and provide for the assessment of the Project's potential for impacts (in particular, from future low flow discharges from the Canal through the treated wetlands); and
- Inform conceptual design of the proposed treatment wetlands based on the water quality in the Canal and in South Lake and the summer base flow in the Canal.

2.1 Monitoring Locations

The dry season monitoring would involve collecting flow and water quality data from the Canal and water quality data from South Lake. **Figure 1** shows the proposed monitoring locations (Vista Grande Canal Station or VGC-1 in the Canal; and LM-1, LM-2, LM-3, and LM-4 in South Lake; discussed below).

Canal: Based on field reconnaissance, VGC-1 has been selected to avoid areas of backwatering or velocity changes that may occur at some constricted points along the Canal. Due to very low base flow (≤0.6 cfs) observed in the Canal during the summer, flow will be monitored through combined use of a V-Notch weir of known dimensions with associated pressure transducer (see **Figure 2** at the end) to monitor extreme low flows up to 0.6 cfs, as well as an ISCO Area-Velocity continuously recording data logger, to monitor higher flows exceeding the design capacity of the V-Notch weir (such as from rainfall events). A hand-held water quality meter will be used to measure pH, DO, and temperature and samples will be collected for laboratory analysis of specific constituents, as described in Section 2.2 below.

South Lake: The proposed four monitoring locations for South Lake have been identified based on review of historic data (Kennedy/Jenks, 2010) and the proposed discharge location of the stormwater from the treatment wetlands. Continuously recording (hourly) water quality loggers will be installed at these locations to record pH, DO, specific conductance, and temperature. Depending on the location, the loggers will record water quality at multiple depths (see **Table 1** in Section 2.2).

Figure 1
Proposed Vista Grande Canal and South Lake Monitoring Locations

- **Station LM-1** is located close to the proposed discharge point midway across the SFPUC's sewer transport structure separating South Lake Merced and Impound Lake.
- **Station LM-2** is located at a public access floating dock between LM-1 and LM-3 to provide an estimate of the receiving water quality in the close vicinity of the proposed stormwater discharge.

- **Station LM-3** is located approximately 1,000 feet northwest of the SFPUC's sewer transport structure separating South Lake and Impound Lake and adjacent to the existing riprap Canal overflow discharge structure. The loggers here will be installed, with permission, on a temporary marker buoy for the duration of the Project. The water quality data here can serve as backup data in case of equipment malfunction, theft, or vandalism at Station LM-1.

- **Station LM-4** is located at a point that has been used by the SFPUC for monitoring water quality in the South Lake since 1997 and has been determined to be representative of the overall water quality of South Lake (Kennedy/Jenks, 2010). LM-4 has been selected for collecting samples for a more detailed water quality analysis (see **Table 2** in Section 2.2), to be consistent with the location (e.g., South Lake Merced Pump Station) used for long-term quarterly water quality monitoring conducted by the SFPUC. This will allow comparison of the 2011 dry season monitoring data to the larger historic record. Field data and analysis of existing conditions suggest that Lake Merced does not experience persistent, seasonal stratification, but rather stratifies weakly and intermittently in the summer to late fall of some years (EDAW, 2004) (Kennedy/Jenks, 2010), but is otherwise fairly well mixed given its shallow depth and the prevailing winds. . Surface water monitoring (i.e., from 0 to 5-foot depth) is also intended to be representative of the receiving water quality in that portion of the water column most likely to be influenced by the proposed low flow summer discharges from the proposed treatment wetlands.

2.2 Monitoring Methodology

The proposed water quality monitoring will be conducted by:

- Monitoring dry season base flow at VGC-1, and

- Both directly measuring water quality constituents and collecting samples for laboratory analysis at all the locations in the Canal and South Lake as identified in Figure 1.

Direct measurements will involve measuring pH, DO, conductivity, and temperature, using a standard hand-held water quality meter. The samples will be collected using standard accepted field methods and delivered to a commercial lab for analysis of water quality constituents summarized in **Table 2**.

Tables 1 and 2 shows the monitoring protocol proposed for the dry weather season at all locations. **Table 2** lists the proposed water quality constituents that will be monitored in at VGG-1 and LM-4. The constituents listed are based on a review of prior SFPUC reports and data and the RWQCB comment letter dated May 19, 2011. The list includes key constituents that were sampled previously by the SFPUC, to ensure consistency with long-term historic records, and/or constituents identified by regulatory agencies for environmental and human health protection (e.g., constituents appearing on the Section 303(d) list). **Table 3** provides the tests and detection limits along with the rationale for each constituent that would be tested under this plan.

TABLE 1. PROPOSED MONITORING PROTOCOL FOR DRY WEATHER SEASON (DIRECT MEASUREMENT)

Constituent	Location	Depth (feet)	Frequency of Measurements
Vista Grande Canal*			
Flow	VGC-1	-	Continuous, hourly
pH**	VGC-1	-	Twice a month
DO**	VGC-1	-	Twice a month
Temperature**	VGC-1	-	Twice a month
Conductivity**	VGC-1	-	Twice a month
South Lake Merced			
pH, DO, temperature, conductivity	LM-1	Surface (<5)	Continuous, Hourly
pH, DO, temperature, conductivity	LM-2	Surface (<5), near bottom	Continuous, Hourly
pH, DO, temperature, conductivity	LM-3	Surface (<5), near bottom	Continuous, Hourly
pH, DO, temperature, conductivity	LM-4	Surface (<5), 10, 15, near bottom	Continuous, Hourly
pH, DO, temperature, conductivity	LM-1,2,3,4	Manual depth profiles at one-foot intervals	Twice a month

* Monitoring is proposed to occur at a frequency of twice every month, as conditions allow. However, during summer months, flow may be absent in Vista Grande Canal. If sampling cannot be completed due to lack of flow during summer months, the sample schedule and methodology will be revised as appropriate.

** pH, DO, conductivity and temperature will be measured manually twice or thrice during each individual field monitoring event (twice per month).

TABLE 2. PROPOSED MONITORING PROTOCOL FOR DRY WEATHER SEASON (SAMPLING AND LABORATORY ANALYSIS)

Constituent	Location		Sampling Frequency
	Canal	South Lake Merced	
Nutrients: Total phosphorous [P], orthophosphate, Total Kjeldahl Nitrogen (TKN), ammonia, nitrate	VGC-1	LM-4 Surface (<5 feet)	Twice a month
Chemical Oxygen Demand	VGC-1		Twice a month
Biochemical Oxygen Demand	VGC-1		Twice a month
Metals: Lead, Copper, Mercury, Nickel, Zinc	VGC-1		Twice a month
Total suspended solids	VGC-1		Twice a month
Volatile suspended solids	VGC-1		Twice a month
Total dissolved solids	VGC-1		Twice a month
Hardness	VGC-1		Twice a month
Conductivity	VGC-1		Twice a month
TC, FC, EC, Ent., MS-2*	VGC-1		Twice a month
Giardia and Cryptosporidium spp**	VGC-1		Once a month
Human Bacteroidales**	VGC-1		Once a month
Chlorophyll a	-		Twice a month
Secchi Depth	-		Twice a month

* TC=Total Coliform, FC=Fecal Coliform, EC=E.Coli, Ent=Enterococcus, MS-2=Male Specific Phage

*******Giardia, Cryptosporidium spp., and* Human *Bacteroidales will be tested once a month.*

TABLE 3. LABORATORY METHODS AND RATIONALE FOR PROPOSED CONSTITUENTS FOR MONITORING

Constituent	Laboratory Test Method	Detection Limits	Type /Indicator / Purpose of Constituent
Dissolved oxygen, pH	-	-	303(d) Impairment evaluation
Temperature	-	-	Dissolved oxygen percent saturation calculation
Total phosphorous [P]	EPA 365.1	0.04 mg/L	Nutrients (factor in eutrophication)
Orthophosphate and Nitrate	EPA 300.1	0.1 mg/L	
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	0.2 mg/L	
Ammonia	EPA 350.1	0.05 mg/L	
Chemical Oxygen Demand	SM 5220D	10 mg/L	Oxygen demand (factor in ambient dissolved oxygen concentration)
Biochemical Oxygen Demand	SM 5210B	4 mg/L	
Total Metals	EPA 200.8	Pb, Cu, Ni (0.1 µg/L) Zn (1 µg/L)	Metals (potential aquatic life impacts)
Mercury	EPA 1631	0.005 µg/L	Bioaccumulation potential (in fish tissue)
Dissolved Metals	E200.8 (filtered)	Pb, Cu, Ni (0.5 µg/L) Zn (5 µg/L)	CTR water quality objectives are expressed as the dissolved metals fraction
Total suspended solids (TSS)	SM 2540D	1 mg/L	Solids loading indicator
Volatile suspended solids (VSS)	SM 2540D	4 mg/L	Organic matter content in TSS
Total dissolved solids (TDS)	SM 2540C	10 mg/L	Mineral content
Hardness	SM 2340B & 200.7	1 mg CaCO3/L	Calculation of fresh water quality objectives
Total Coliform, Fecal Colifom, E. coli*	SM 9222	1 cfu/100 ml	Pathogen Indicators

TABLE 3 (cont.). LABORATORY METHODS AND RATIONALE FOR PROPOSED CONSTITUENTS FOR MONITORING

Constituent	Laboratory Test Method	Detection Limits	Type /Indicator / Purpose of Constituent
Enterococcus*	EPA 1600	1 cfu/100 ml	Pathogen Indicators
MS-2	EPA 1602	1/100 ml	
Human Bacteroidales*	Multiple Markers	1 pfu/vol analyzed	
Giardia and Cryptosporidium spp*	EPA 1623	0.1 cyst of oocyst/L	Human pathogens
Chlorophyll a	SM 10200 Part 4	50 µg/L	Phytoplankton/ algal growth indicator
Secchi Depth	-	-	Lake clarity

Note: * Detection limits shown are target values. Actual detection limits will depend on amount of sample able to be filtered.

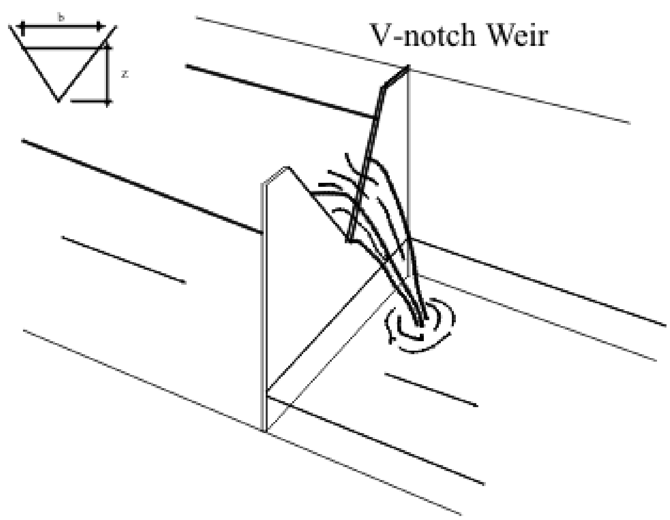

Figure 2
Example of V-Notch Weir for Flow Monitoring

REFERENCES

EDAW and Talavera and Richardson, *Task 4 Technical Memorandum: Impacts to Water Quality, Vegetation, Wildlife and Beneficial Uses, Lake Merced Initiative to Raise and Maintain Lake Level and Improve Water Quality*, Prepared for the San Francisco Public Utilities Commission, September, 2004.

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Final 2011-2012 Wet Season Water Quality Monitoring Plan

Vista Grande Drainage Basin Improvement Project

November 17, 2011

1.0 INTRODUCTION

The City of Daly City (Daly City) has prepared this water quality monitoring plan in support of the South Lake Merced Alternative of the Vista Grande Drainage Basin Improvement Project (Project). Lake Merced is the largest freshwater lake located within the City and County of San Francisco (CCSF) and it is operated and maintained by the San Francisco Public Utilities Commission (SFPUC). The northwestern area of Daly City and unincorporated portions of San Mateo County drain into the Vista Grande portion of Daly City's stormwater collection system. The underground collection system conveys the storm flows to the Vista Grande Canal (Canal) and then into the Vista Grande Tunnel (Tunnel), which discharges through the Daly City outfall structure into the Pacific Ocean at the beach below Fort Funston. Historically wet weather flows in excess of the capacity of the Canal and the Tunnel have occasionally resulted in local flooding and overflows across John Muir Drive into South Lake Merced, causing property damage, bank erosion, traffic nuisances, and public safety issues (RMC, 2006).

The Lake Merced Alternative (the Project) would route a portion of wet season storm flows from the Vista Grande Canal directly to South Lake Merced (South Lake) and a smaller portion of dry and wet season flows from the Canal through a proposed treatment wetland to South Lake.

2.0 MONITORING PLAN OBJECTIVES

The intent of the monitoring plan is to provide specific water quality data needed to support project design and environmental analysis for California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) documentation and to facilitate project review by the San Francisco Bay Regional Water Quality Control Board (RWQCB). To that effect, the monitoring data will help quantify wet season flow and establish baseline water quality within the Canal and expand on the existing water quality data set for South Lake. This monitoring plan has been developed based on a review of water quality monitoring data previously collected by Daly City and the SFPUC (Kennedy/Jenks, 2010).

The scope of this monitoring plan has been developed based on the System Understanding and Assessment Strategy (**Attachment A**) that has been developed to provide an understanding of current water quality conditions in South Lake Merced, the processes and factors governing water quality in South Lake Merced, how the contribution of Vista Grande flows to South Lake Merced might alter existing water quality conditions in South Lake Merced, and a strategy for assessing impacts to existing water quality conditions. Based on the assessment needs identified in the System Understanding and Assessment Strategy, specific information needs, analytical approaches, and data criteria have been identified within the Water Quality Data Objectives Matrix (**Attachment B**). This monitoring plan incorporates the analytic strategy and data objectives developed in these attached documents.

3.0 PROPOSED MONITORING PLAN

Wet season monitoring of flow and water quality will be conducted in the Canal from approximately November 20, 2011 to May 31, 2012. Water quality in South Lake will be monitored during the same period to assess the baseline conditions of the receiving waters for the project.

The objectives of the wet season monitoring are to:

- Provide flow and water quality data to characterize baseline conditions in the Vista Grande Canal during winter months, including storm event flows and base flow (which is typically lower than summer base flow due to reduced irrigation return flow);
- Characterize the baseline water quality of the receiving waters (South Lake) during the proposed stormwater diversion period to provide for the assessment of the Project's potential impacts; and
- Provide data that will support development of the conceptual design of the proposed treatment wetlands based on the water quality and the winter base flow in the Canal.

Additional specific data objectives are identified in the Water Quality Data Objectives Matrix (Attachment B).

3.1 Monitoring Locations

The wet season monitoring would involve collecting flow and water quality data from the Canal and water quality data from South Lake. **Figure 1** shows the proposed monitoring locations (Vista Grande Canal Station, VGC-1; and South Lake stations, LM-1, LM-2, LM-3, and LM-4; discussed below).

Canal

VGC-1 has been selected for hydrologic monitoring and water quality sampling to avoid areas of backwatering or velocity changes that may occur at some constricted points along the Canal.

Figure 1
Proposed Vista Grande Canal and South Lake Monitoring Locations

South Lake

The proposed four monitoring locations for South Lake have been identified based on review of historic data (Kennedy/Jenks, 2010) and the proposed discharge location of the stormwater. Locations within South Lake were selected to provide representative data as follows:

- **Station LM-1** is located close to the proposed discharge point midway across the SFPUC's sewer transport structure separating South Lake Merced and Impound Lake. One multiprobe, continuously logging, water quality sonde (pH, DO, temperature, and conductivity) has been installed here at a depth of approximately 1.5-feet depth[1].

- **Station LM-2** is located at a public access floating dock. Between LM-1 and LM-3, the pH, DO, temperature, and conductivity values at LM-2 will provide an estimate on the receiving water quality in the close vicinity of the proposed stormwater discharge. Two loggers have been installed here at the surface and approximately 8-feet of depth.

- **Station LM-3** is located approximately 1,000 feet northwest of the SFPUC's sewer transport structure separating South Lake and Impound Lake and adjacent to the existing riprap Canal overflow discharge structure. Two loggers have been installed here at the surface and approximately 15-feet of depth on a temporary marker buoy for the duration of the Project. The water quality data (pH, DO, temperature, and conductivity) here can serve as backup data in case of equipment malfunction, theft, or vandalism at Station LM-4 and will also capture water quality changes that may result if Canal water flows into South Lake as a result of a Canal overflow or intentional diversion during a major storm.

- **Station LM-4** is located at a point that has been used by the SFPUC for monitoring water quality in South Lake since 1999 and is representative of the overall health and water quality of South Lake (Kennedy/Jenks, 2010). As part of this proposed monitoring plan, LM-4 has been selected for collecting samples for a more detailed water quality analysis (see **Table 1** in Section 2.2), to be consistent with the location (e.g., South Lake Merced Pump Station) used for long-term quarterly water quality monitoring conducted by the SFPUC, allowing comparison of the 2011-2012 wet season monitoring data to the larger historic record. Surface water sampling (i.e., from 0 to 5-foot depth) would be representative of the receiving water quality in that portion of the water column most likely to be influenced by the proposed stormwater discharges from the Canal. In addition, it is noted that the historical data suggests the lake is well mixed during winter months due to low air temperatures and wind action[2].

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[1] Note: max depth at location LM-1 is 2-feet.

[2] Due to health and safety concerns for open water sampling during storm event, LM-2 (public dock) will be used as a back-up location for surface water quality sampling during winter months. As noted in the text, data from 12 years of monitoring by the SFPUC indicate that Lake Merced is well mixed during winter months and surface water

3.2 Monitoring Methodology

The proposed wet season water quality monitoring will be conducted using the following techniques:

- Basic water quality constituents (dissolved oxygen, pH, temperature, and conductivity) will be recorded continuously throughout the wet season using multi-probe water quality sondes with logging capability at all the locations in the Canal and South Lake as identified in Figure 1. The sondes are located at depths identified in **Table 2**.
- Hydrologic characterization of stormflow within the Canal will utilize a continuously recording Area-Velocity meter to capture water depth, velocity, and flow within the Canal in real time.
- Detailed water quality characterization of stormflow and South Lake receiving waters will be conducted through collection of water quality samples for laboratory analysis at VGC-1 and LM-4 (or LM-2) as identified in Figure 1. Detailed water quality characterization both in the Canal and in South Lake would be conducted during and following, precipitation events that result in stormflow within the Canal above base flow conditions.
- Detailed water quality characterization of base flow in the Canal will be conducted through collection of water quality samples for laboratory analysis.

The following sections describe the detailed methodologies being employed for water quality and hydrologic characterization of the Canal and South Lake.

Canal

Rainfall: In order to correlate Canal flow to precipitation events, rainfall will be monitored at a local rain gage (Station AS891) located approximately 2.5 miles northwest of Vista Grande Canal at Ocean Beach at an elevation of 33 feet via the MesoWest weather portal online (MesoWest, 2011), administered by the University of Utah, Department of Atmospheric Sciences. Raw tipping bucket rainfall data will be downloaded for Station AS891 monthly, standardized to Pacific Standard Time, and processed to calculate total cumulative rainfall (inches) for the monitoring period; total daily rainfall (inches) for the monitoring period; and cumulative hourly rainfall (inches per hour) for each storm event for which water quality was characterized by sample collection and laboratory analysis (approximately 6 events).

Flow: To monitor flow within the Canal, an ISCO 2150 Area-Velocity meter will be installed at the VGC-1 monitoring station (Figure 1). The ISCO 2150 records continuous measurements of water depth (foot) and water velocity (foot/second). Channel dimensions (from survey data) and channel form (trapezoidal) allow the Area-Velocity meter to report real time flow (cfs). The velocity sensor will be mounted onto a pre-fabricated stainless steel plate which will be fixed in place on the Canal bottom. Flow data will be

samples at LM-2 would be representative of surface water quality within Lake Merced within the vicinity of the proposed discharge.

used to generate hydrographs of Canal flows. In addition, hydrographs will be generated to correlate water quality data to the timing and volume of storm events sampled.

<u>Water Quality Monitoring by Direct Measurement</u>: For continuous direct measurement of basic water quality constituents of stormflow within the Canal, a multi-probe water quality sonde with logging capability will be installed in the Canal within a PVC stilling well, mounted onto the Canal bank (Olympic Club side). The sonde will continuously record dissolved oxygen levels, pH, and temperature (15 minute interval, synced to Area-Velocity recorder measurements).

<u>Detailed Stormwater Quality Characterization</u>: The intent of the detailed water quality monitoring methodology is to characterize water quality in the Canal (storm flows and base flows proposed for diversion). Table 1 details the water quality constituents proposed for wet season water quality characterization of Canal storm and base flows.

Sampling of the Canal storm flows has two basic objectives. The primary objective is to estimate the constituent loading of storm events. A secondary objective is to measure the variation of pollutant concentrations within each storm event. To meet the primary objective, an Event Mean Concentration (EMC) will be calculated for each storm event and multiplied by the total event flow volume. Due to the flashy nature of urban watersheds, the Vista Grande Canal experiences short durations of storm event runoff and stormflow receds to baseflow levels rapidly following cessation of precipitation.It is therefore problematic to successfully collect grab samples manually. As a result, samples from the Canal will be collected using an ISCO automatic water sampler. To enable calculation of the EMC, flow-interval (volumetric paced) sampling will be used. A pre-determined volume of water (approximately 100mL to 900mL) will be sampled at pre-determined flow rate (e.g. for every 100,000 gallons) that is tracked by the area-velocity meter. Each targeted storm event will be evaluated for intensity and duration using weather forecasts, and the autosampler will be programmed via a telemetry device. In addition to being informed by weather forecasts, programming will be informed by the analysis of previous storm hydrographs and the results of prior sampling events. The following sampling parameters will be determined prior to each sampling event.

- Flow threshold trigger: establishes the point at which the auto sampler will begin sampling a storm event. The flow threshold may range from 2 to 20 cfs, depending on the expected intensity and duration of a flow event. The goal will be to use the lowest flow threshold in order to capture the greatest extent of the hydrograph (and therefore reduces error in calculating the EMC), without triggering a number of smaller pre-storm runoff events that could result in exceeding the bottle capacity before the storm event is finished.

- Sample size: a smaller sample size allows for more samples to be taken (which reduces error in calculating the EMC), however a smaller sample size requires more frequent back flushing of the sampling line, which can limit the ability to sample quickly enough at the peak of the hydrograph (and introduce error in the EMC calculation). As noted, sample sizes are expected to range from 100mL to 900mL.

- Flow interval: determines the rate (volumetric or time paced) at which samples will be taken. The rate will be adjusted according to the expected intensity and duration, and selected sample size. The autosampler will be connected to an ISCO Area-Velocity meter and set to collect water quality samples from the Canal at pre-determined flow thresholds to allow collection of water quality samples during precipitation events that generate Canal storm flow.

The autosampler will sequentially collect samples in 24 (900mL) bottles, filling one bottle before starting the next. At the completion of the sampling, field staff will create a composite event sample by consolidating all or a portion of the individual bottles into one large container. This large container will then be used to fill constituent sample bottles. Because the sampling will be flow weighted, if the storm event is adequately captured by the autosampler this composite sample will provide the EMC for individual constituents. Adequate precautions will be required to ensure the contributing volume from the 24 individual sample bottles is accurately measured, and that settling of the samples is controlled. Water quality samples will be collected from the autosampler for delivery to a commercial lab for analysis within 24 hours of a precipitation event.[3]

To sample the entire suite of constituents indentified in Table 1, a minimum event composite sample of 16.65 liters will be required. In the event that an inadequate volume of water is collected by the autosampler, the sample for giardia and cryptosporidium will be not be included, reducing the minimum event composite sample to 9.08 liters. If less than 9.08 liters is representatively sampled, constituents will be prioritized, or the sampling event will be concluded without sending the samples for laboratory analysis.

Using separate sample bottles in the autosampler instead of one large composite sample container will facilitate the secondary objective – to measure the variation of pollutant concentrations across the storm hydrograph (e.g. pollutant concentrations characterizing the rising versus falling limb of the hydrograph) – to be achieved. If an adequate volume of water is remaining in the 24 individual sample bottles, then this remaining sample volume will be used to develop 1-3 composite samples of the hydrograph. Three potential groupings will be used. The first grouping will consist of two groups, one composite group below a flow threshold, and another group above the flow threshold. This will provide concentration data based on the flow in the canal and may assist in developing operational diversion criteria. The second potential grouping will be to develop 1-3 composite samples relating to the rising limb, peak flow, and falling limb of the hydrograph. This will provide concentration data based on the sequence of flows. If only 1 sample is taken (for instance of the rising limb), this sample would provide some characterization of that segment of the hydrograph as compared to the EMC. The following

[3] Due to the flashy nature of the Vista Grande Basin and Canal, and depending on the timing of precipitation event, sample collection and delivery to a commercial lab will need to occur during business hours Monday to Friday. This is a constraint for water quality analysis that reflects commercial lab operation hours, sample hold times, and staff health and safety considerations. Microbiological constituents will be collected and shipped to the lab as expeditiously as possible.

constituents (listed in order of priority) would be sampled to characterize variation within the hydrograph:

Constituent	Sample Size (L)
Total Suspended Solids	1
Orthophosphate & Nitrate as N	0.25
Total Metals (Pb, Cu, Ni)	0.25
Total Metals (Zn)	0.25
Mercury	0.5
Bacteria	0.5

Base flow samples would be collected to characterize the quality of water that would be diverted to South Lake through the proposed treatment wetlands. Six samples would be taken periodically through the wet season (approximately 1 per month), subject to adequate base flow volume. Table 1 lists the laboratory methods for the proposed water quality constituents that will be monitored at VGC-1 (and at LM-4, as detailed below).

South Lake

Water Quality Monitoring by Direct Measurement: For continuous direct measurement of basic water quality constituents for receiving waters, multi-probe water quality sondes with logging capability will be installed at various locations (LM-1 through LM-4 as shown on Figure 1) and at a range of depths (Table 2) to characterize basic receiving water quality both spatially and throughout the water column (where appropriate). The sondes will record dissolved oxygen levels, pH, conductivity, and temperature on an hourly interval, allowing comparative analysis of event based and seasonal water quality trends between the Canal stormwater and South Lake receiving water.

Detailed Receiving Water Quality Characterization: To facilitate comparative analysis and impact assessment, water quality sample collection from South Lake will be synchronized with collection of water quality samples from the Canal. To the extent possible, samples will be collected within 24 hours of a precipitation event (for 6 events) that generates stormflow and autosampler collection within the Canal. Water quality samples collected for laboratory analysis will be collected from station LM-4[4] (Figure 1) surface waters (< 5 foot depth; rationale for location and depth provided in Section 2.1, above). Table 1 details the water quality constituents proposed for wet season water quality characterization of South Lake receiving waters. All samples will be collected using standard accepted field methods and delivered to a commercial lab for analysis of the water quality constituents summarized in Table 1. Additionally, subsequent water quality samples will be collected from LM-4 approximately 24 hours after the cessation of a precipitation/runoff event for analysis of microbiological

[4] Or alternately LM-2 as discussed in Section 3.1, above.

constituents (indicator bacteria as detailed in Table 1) to characterize and assess the rate of bacterial die-off in Lake Merced following contribution of stormflows as part of a Microbial Risk Assessment (see Attachment B for a description of specific data objectives). Table 1 lists the laboratory methods for the proposed water quality constituents that will be monitored at LM-4.

Stormwater Diversion: To facilitate the analysis of indicator bacteria levels, stormwater diversions previously conducted by Daly City and the SFPUC (as described in EOA, 2011) may be conducted during the 2011-2012 wet season to expand on the analysis of potential project-related impacts on bacteria levels in South Lake. The intent of stormwater diversions is to convey a volume of water that more closely approximates volumes that would be diverted by the project. The maximum diversion in the pilot project was 5.4 million gallons, however most diversion volumes were much smaller (ranging from 0.09 to 3.3 million gallons). If feasible during storm events of large magnitude and extent, stormwater would be diverted through the Continuous Deflection System (CDS) established for the pilot project to screen trash and disperse flows into the riparian buffer of South Lake. Indicator bacteria levels at near shore and offshore would be monitored to characterize dilution. A series of 2 samplings would occur at a minimum of 3 locations in South Lake. Sampling would occur at the end of the event and a second sampling would be taken 24 hours following the first sample event to characterize indicator bacteria die-off. Sampling of Vista Grande stormwater would occur during the diversion to characterize indicator bacteria/pathogen levels of the water diverted to South Lake.

TABLE 1. PROPOSED MONITORING PROTOCOL FOR WET WEATHER SEASON (SAMPLING AND LABORATORY ANALYSIS)

Constituent	Canal Sampling Frequency (VGC-1)	South Lake Merced Sampling Frequency LM-4 Surface (<5 feet)	Units	Laboratory Test Method	Method Detection Limits	Reporting Limits	Sample Size
Dissolved oxygen (manual)	A target of 6 storm events and 6 base flow samples	A target of 6 storm events with 2 samples per event	mg/L	N/A (field measurement)			
pH (manual)			pH scale				
Temperature (manual)			Degrees Celsius				
Total phosphorous			mg/L	EPA 365.1	0.03 mg/L	0.04mg/L	(1) 1 Liter
Orthophosphate			mg/L	EPA 300.0	0.021 mg/L	0.1 mg/L	(1) 250 ml
Nitrate as N			mg/L	EPA 300.0	0.019 mg/L	0.1 mg/L	Same Container w/ Ortho.
Total Kjeldahl Nitrogen			mg/L	EPA 351.2	0.04 mg/L	0.15 mg/L	(1) 1 Liter
Total Ammonia [as N]			mg/L	EPA 350.1	0.05 mg/L	0.05 mg/L	(1) Liter
Chemical Oxygen Demand			mg/L	SM 5220D	10 mg/L	10 mg/L	(2) 40 ml
Biochemical Oxygen Demand			mg/L	SM 5210B	4 mg/L	4 mg/L	(1) 1 Liter
Total Metals (Pb, Cu, Ni)			µg/L	EPA 200.8	0.1 µg/L	0.5 µg/L	(1) 250 ml
Total Metals (Zn)			µg/L	EPA 200.8	1 µg/L	5 µg/L	(1) 250 ml
Total Mercury			µg/L	EPA 1631	0.0005 µg/L	0.0005 µg/L	(1) 500 ml
Dissolved Metals (Pb, Cu, Ni)			µg/L	E200.8 (filtered)	0.1 µg/L	0.5 µg/L	(1) 250 ml

TABLE 1 (cont.). PROPOSED MONITORING PROTOCOL FOR WET WEATHER SEASON (SAMPLING AND LABORATORY ANALYSIS)

Constituent	Canal Sampling Frequency (VGC-1)	South Lake Merced Sampling Frequency LM-4 Surface (<5 feet)	Units	Laboratory Test Method	Method Detection Limits	Reporting Limits	Sample Size
Dissolved Metals (Zn)	A target of 6 storm events and 6 base flow samples	A target of 6 storm events with 2 samples per event	µg/L	E200.8 (filtered)	1 µg/L	5 µg/L	(1) 250 ml
Total suspended solids			µg/L	SM 2540D	N/A	1 µg/L	(1) 1 Liter
Volatile suspended solids			µg/L	SM 2540D	N/A	4 µg/L	(1) 1 Liter
Total dissolved solids			µg/L	SM 2540C	N/A	10 µg/L	(1) 500 ml
Hardness			mg/L CaCO3/L	SM 2340B & 200.7	1 mg/L CaCO3/L	1 mg/L CaCO3/L	(1) 250 ml
Chlorophyll a			µg/L	SM 10200 Part 4	5 µg/L	5 µg/L	(1) 1 Liter
Total Coliform, Fecal Colifom, E. coli*			cfu/ml	SM 9222	1 cfu/100 ml	1 cfu/100 ml	(1) 200 ml
Enterococcus*			cfu/ml	EPA 1600	1 cfu/100 ml	1 cfu/100 ml	(1) 100 ml
Male Specific Bacteriophage (MS-2)			PFU/100 ml	EPA 1602	1/100 ml	1/100 ml	(1) 100 ml
Human Bacteroidales*			Number of Markers	Multiple Markers	N/A	N/A	(1) 100 ml
Giardia spp*	A target of 6 storm events**		cyst/L	EPA 1623	0.1 cyst of cyst/L	0.1 cyst of cyst/L	(2) 1 Gallon
Cryptosporidium*			oocyst/L	EPA 1623	0.1 cyst of oocyst/L	0.1 cyst of oocyst/L	
Secchi Depth	n/a		Feet	N/A (field measurement)	N/A	N/A	N/A

Notes: * Detection limits shown are target values. Actual detection limits will depend on amount of sample able to be filtered.

** Due to large sample volume requirements for Giardia and Cryptosporidium (2 gallons) and limitations on volumes collected by the autosampler, sampling of these constituents may be forfeited in favor of providing a representative composite sample of the remaining constituents (to estimate event loading) and characterizing the variation of pollutant concentrations across the storm hydrograph.

TABLE 2. PROPOSED MONITORING FOR WET WEATHER SEASON (DIRECT MEASUREMENT)

Constituent	Location	Monitoring Depth (feet)	Frequency of Measurements
pH, DO, temperature, conductivity	VGC-1	Surface*	Continuous (Hourly)
pH, DO, temperature, conductivity	LM-1	Surface** (<5 ft)	Continuous (Hourly)
pH, DO, temperature, conductivity	LM-2	Surface** (<5 ft), near bottom (8 ft)	Continuous (Hourly)
pH, DO, temperature, conductivity	LM-3	Surface** (<5 ft), near bottom (15 ft)	Continuous (Hourly)
pH, DO, temperature, conductivity	LM-4	Surface** (<5 ft), 10 ft, 15 ft, and near bottom (20 ft)	Continuous (Hourly)

* Continuous water quality monitoring within the Canal is only feasible above a depth of 0.5-feet (stormflow), and as such continuous water quality data will be collected for stormflow but not for baseflow.
**Continuous water quality monitoring between zero and up to 5 feet of depth in the Lake are assumed to be representative of surface sampling.

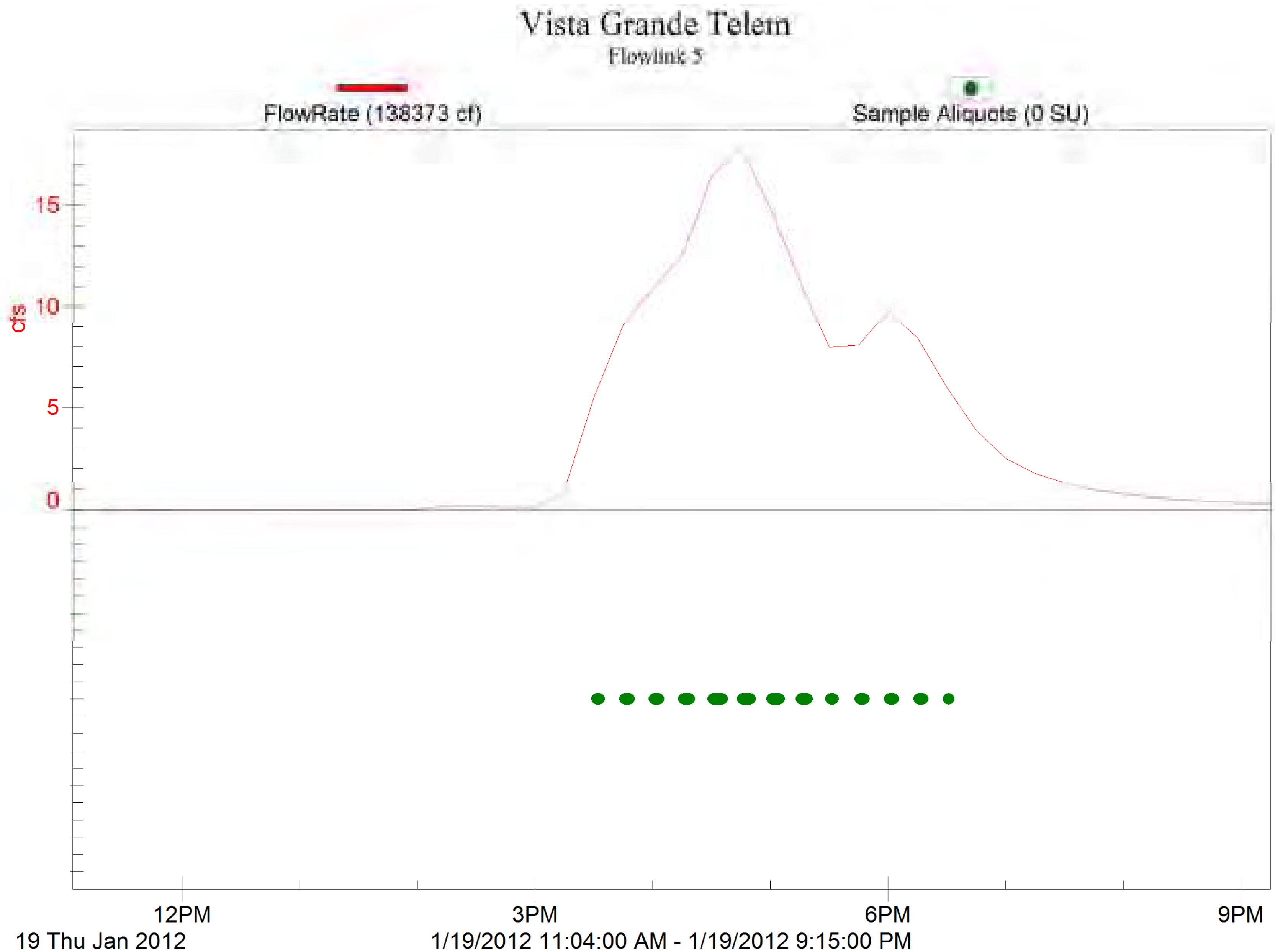
REFERENCES

EDAW, *Lake Merced: Initiative to Raise and Maintain Lake Level and Improve Water Quality, Task 4 Technical Memorandum*, Prepared for the San Francisco Public Utilities Commission, September 2004.

EOA, *Preliminary Water Quality Screening Results, 2003/04 – 2008/09 Wet Weather Seasons, Lake Merced Pilot Stormwater Enhancement Project*, Prepared for the North San Mateo County Sanitation District, June 2011

Kennedy/Jenks Consultants (KJ), *Lake Merced Water Quality Data Organization, Review and Analysis*, Prepared for the San Francisco Public Utilities Commission, 25 January 2010.

RMC, *Vista Grande Watershed Study*, Prepared for the City of Daly City and City and County of San Francisco, 2006.



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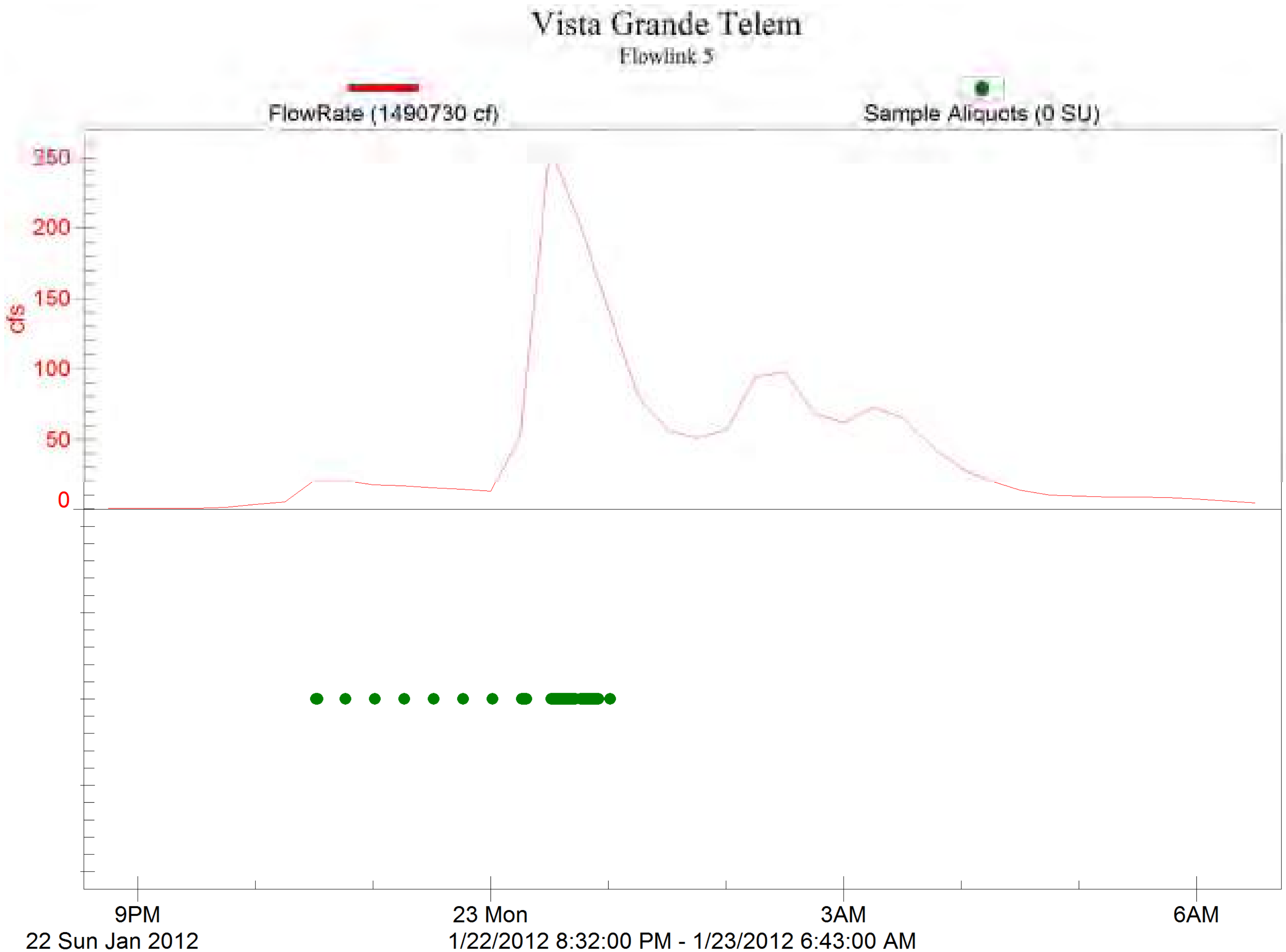
cfs
15
10
5
0
12PM
3PM
6PM
9PM
19 Thu Jan 2012
1/19/2012 11:04:00 AM - 1/19/2012 9:15:00 PM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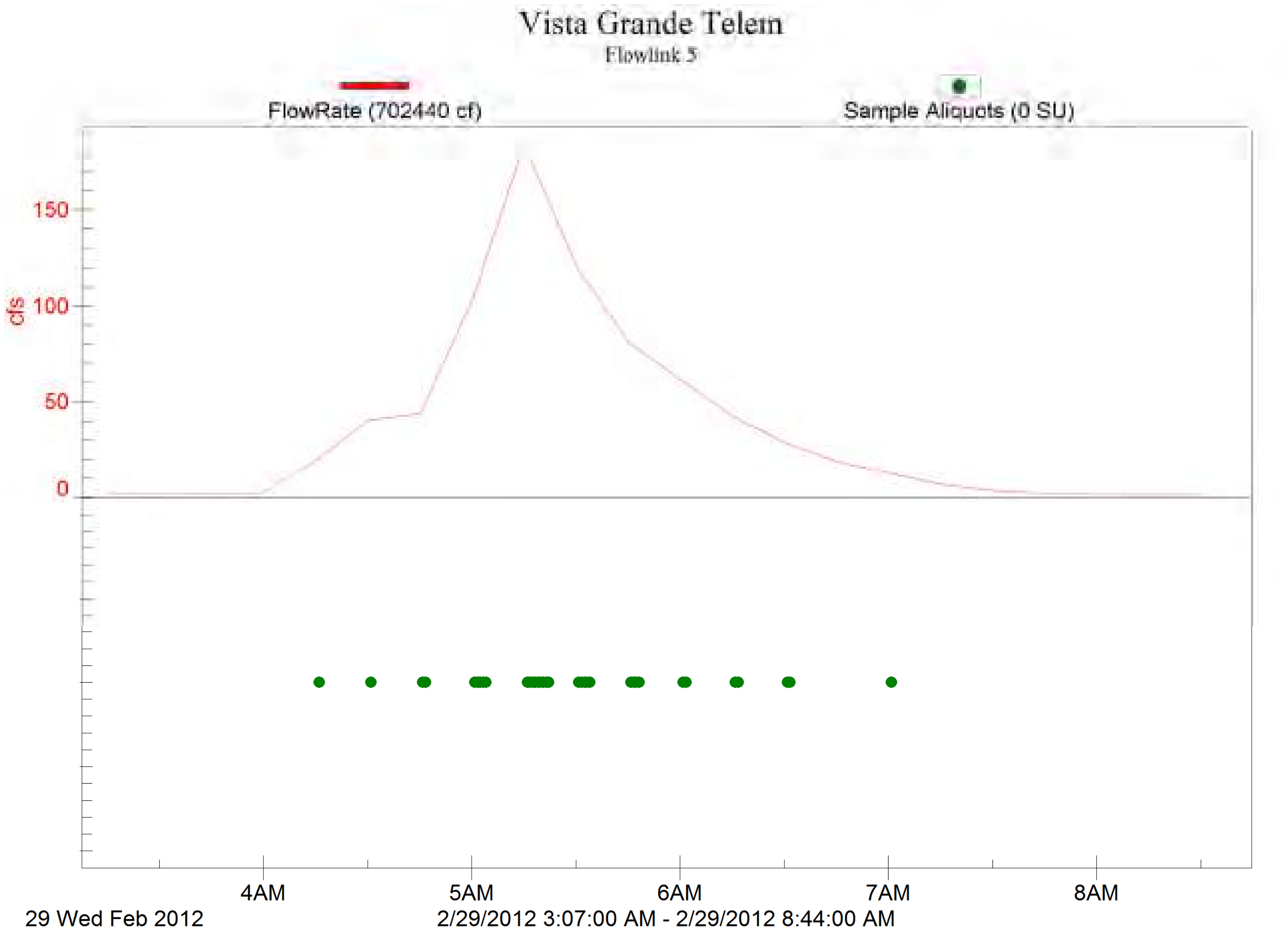
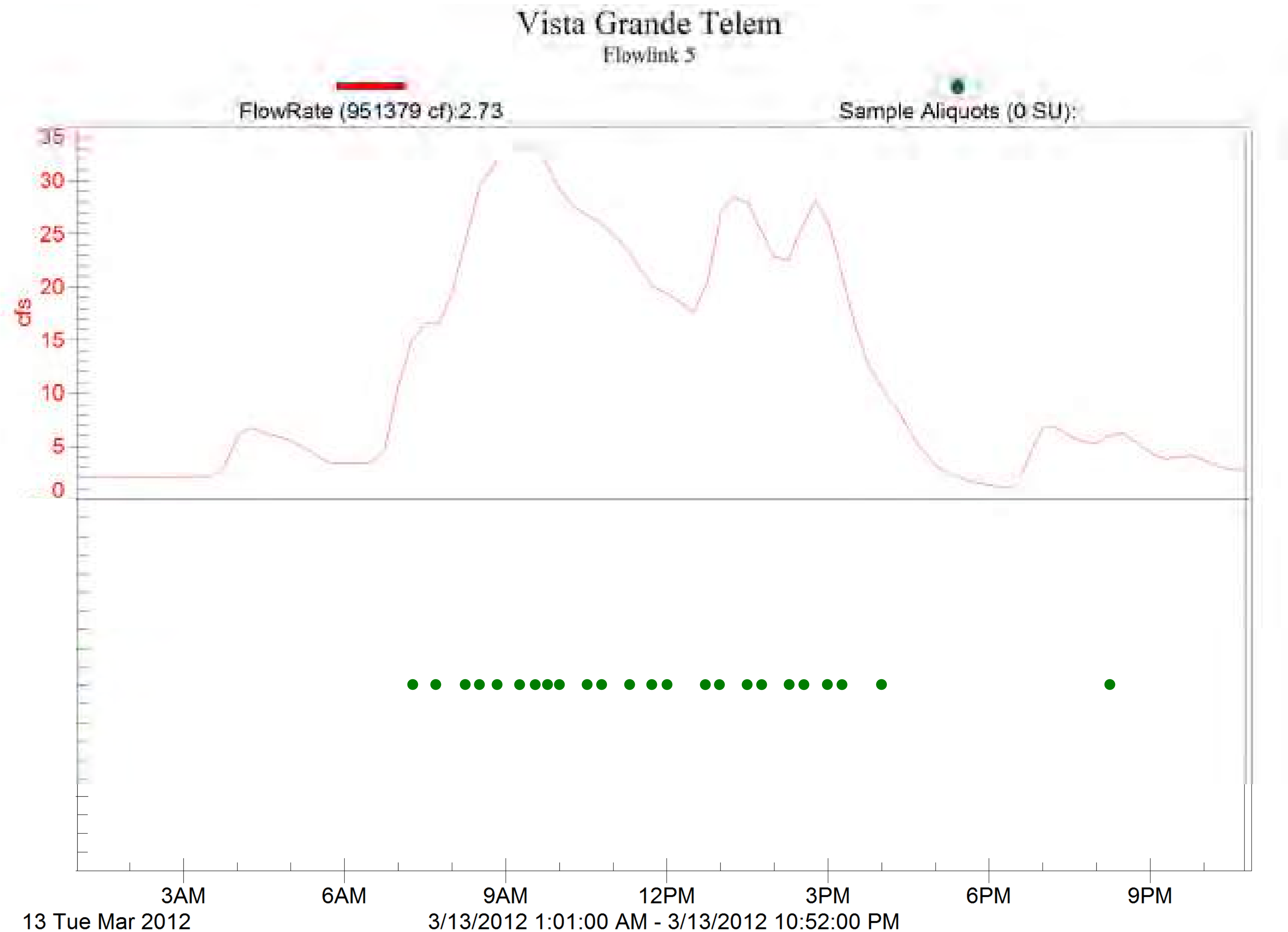
cfs
250
200
150
100
50
0
9PM
22 Sun Jan 2012
23 Mon
3AM
6AM
1/22/2012 8:32:00 PM - 1/23/2012 6:43:00 AM



2-23-0862
Exhibit 6



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30
25
20
15
10
5
0
3AM
6AM
9AM
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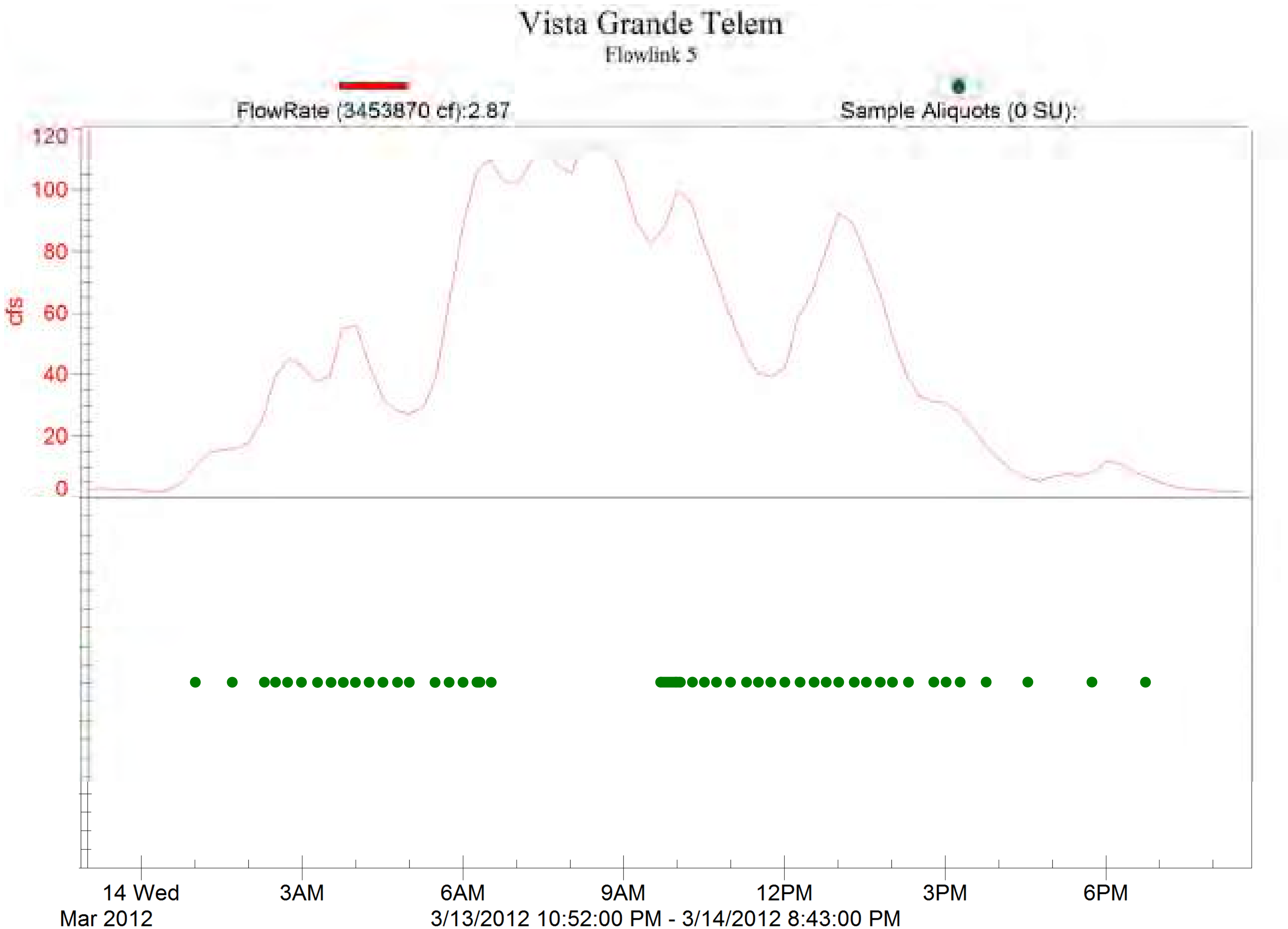
3PM
6PM
9PM
13 Tue Mar 2012
3/13/2012 1:01:00 AM - 3/13/2012 10:52:00 PM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0
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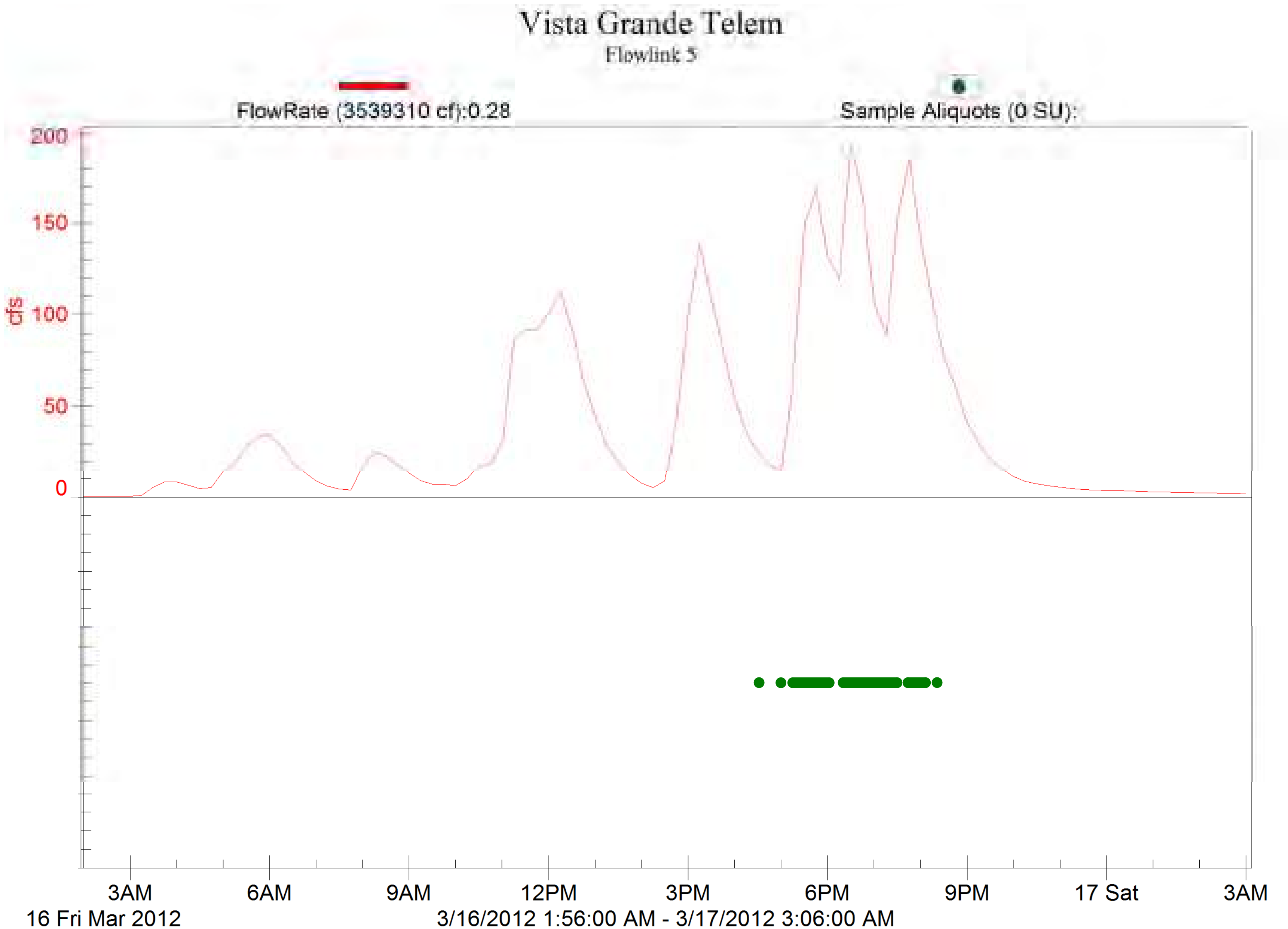
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150
cfs 100
50
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12PM
3PM
6PM
9PM
17 Sat
3AM
16 Fri Mar 2012
3/16/2012 1:56:00 AM - 3/17/2012 3:06:00 AM

Dry Season Monitoring Water Quality Results

Constituents	Units	RL[a]	MDL[a]	2011 DRY SEASON WATER QUALITY RESULTS — Sample Date (conducted concurrently in VGC and LM) — Vista Grande Canal						Lake Merced					
				8/17	9/1	9/15	9/30	10/13	10/27	8/17	9/1	9/15	9/30	10/13	10/27
Nutrients															
Total phosphorous [P]	mg/L	0.04	0.03	0.18	0.15	0.21	0.4	0.29	0.19	0.067	0.12	0.098	0.12	0.13	0.21
Orthophosphate as P	mg/L	0.1	0.021	<0.1	0.06[J]	0.099	0.27	0.26	0.032[J]	<0.1	0.05[J]	0.096[J]	<0.1	0.12	<0.1
Nitrate as N03	mg/L	0.45	0.085	14	21	20	17	17	21	<0.45	0.13[J]	0.31[J]	0.31[J]	0.24[J]	<0.45
Nitrate as N	mg/L	0.1	0.019	3.1	4.7	4.4	3.8	3.9	4.6	<0.1	0.03[J]	0.07[J]	0.07[J]	0.06[J]	<0.1
Total Kjeldahl Nitrogen (TKN)	mg/L	0.15	0.07	1.5	0.91	0.97	0.84	0.61	0.71	1.8	1.1	1.5	1.6	1.6	1.5
Ammonia as N	mg/L	0.05	0.05	0.16	0.32	0.05	0.057	0.087	0.069	0.074	0.05	0.05	0.05	0.05	0.14
Chlorophyll a [b] *	µg/L	5	5	-	-	-	-	-	-	<50	50	-	<5	68	32
Oxygen Demand															
Chemical Oxygen Demand (COD)	mg/L	10	10	33	22	22	20	22	17	26	25	34	32	34	30
Biochemical Oxygen Demand (BOD)	mg/L	4	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	4.1	<4
Metals (Total)															
Lead (Pb)	µg/L	0.5	0.1	1.1	0.86	1.5	1.1	0.82	0.57	<0.5	0.11[J]	0.14[J]	<0.5	<0.5	0.14[J]
Copper (Cu)	µg/L	0.5	0.1	6	5.1	5.6	4.3	5.5	5.7	<0.5	<0.5	<0.5	<0.5	0.58	0.51
Nickel (Ni)	µg/L	0.5	0.1	4.6	4.1	4.7	4.9	6.6	5.2	<0.5	<0.5	0.37[J]	<0.5	<0.5	3.6
Zinc (Zn)	µg/L	5	1	20	15	16	22	33	22	<5	2.2[J]	2[J]	<5	<5	<5
Mercury (Hg)	ng/L	0.5	0.3	<0.025	1.7	2	2.4	2.5	2.3	<0.025	<0.5	<0.5	<0.5	<0.5	<0.5
Metals (Dissolved)															
Lead (Pb) *	µg/L	0.5	0.1	-	-	0.48[J]	<0.5		0.14[J]	-	-	<0.5	<0.5	<0.5	<0.5
Copper (Cu) *	µg/L	0.5	0.1	-	-	5	<0.5	2.7	4	-	-	<0.5	5.1	<0.5	<0.5
Nickel (Ni) *	µg/L	0.5	0.1	-	-	4.3	<0.5	5.8	3.7	-	-	0.16[J]	5.1	<0.5	<0.5
Zinc (Zn)	µg/L	5	1	-	-	11	<5	22	14	-	-	5.3	19	<5	<5
Physical Parameters															
Total Suspended solids (TSS)	mg/L	1	-	2.7	34 (DF=10)	2.2	6.3	2.9	4.1	12.9	142 (DF=20)	13.4	17.1	92 (DF=20)	6.8 (DF=2)
Volatile Suspended Solids (VSS)*	mg/L	4	-	-	-	<4	-	<4	<4	-	-	12	-	9.2	<4
Total Dissolved Solids (TDS)	mg/L	10	-	392	468	546	427	461	408	425	390	442	403	371	380
Hardness	mg CaCO3/L	1	-	240	270 (DF=10)	260	240	260 (DF=10)	260	210	210	230	230	220 (DF=10)	250
Bacteria/ Organisms															
Total Coliform	cfu/100 mL	-	-	140,000	16,000	15,000	9,000	14,800	5,100	<100	6	16	32	30	13
Fecal Coliform	cfu/100 mL	-	-	5,700	120	3,400	520	1,440	470	30	6	15	26	77	11
E. coli	cfu/100 mL	-	-	20,000	1,000	2,000	6,000	4,600	2,900	<100	6	16	28	24	13
Enterococcus	cfu/100 mL	-	-	6,300	480	480	600	1,770	45	<10	2	7	60	42	19
MS-2 (Bacteriophage, Male Specific)	pfu/mL	-	-	20	<1	<1	7	322	6	<1	<1	<1	1	<1	3
Cryptosporidium spp. *	oocysts/L	-	-	<0.23	NS	<0.14	NS	0.1	NS	<0.25	NS	<0.14	NS	<0.1	NS
Giardia *	cysts/L	-	-	<0.23	NS	3.58	NS	<0.1	NS	<0.25	NS	<0.14	NS	<0.1	NS
Bacteroidales - General *		-	-	Present	NS	Present	NS	Present	NS	Present	NS	Present	NS	Present	NS
Bacteroidales - Human *		-	-	Present	NS	ND	NS	ND	NS	Present	NS	ND	NS	ND	NS

NOTES:

[a] Reporting Limits (RLs) and Method Detection Limits (MDLs) are based on a Dilution Factor of 1 (DF=1).
Reporting Limit (RL) corresponds to the lowest amount of an analyte in a sample that can be quantitatively determined with acceptable precision and accuracy by the laboratory.
The Method Detection Limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

[b] Chlorophyll a is only relevant to Lake Merced (LM); not relevant to VGC.

< Not detected or are present below the reporting limits.

[J] Analyte detected below Reporting Limit (RL) but above Method Detection Limit (MDL) and therefore the reported concentration is qualified as estimated and not considered quantified.

* There are less than 6 dry season samples for this constituent.

DF= Sample has a dilution factor higher than 1. The sample result must be increased by a factor corresponding to the dilution factor.

ND represents a non-detect result from laboratory analysis.

NS/- represents a constituent for which no sample was collected or a day where no sampling occurred.

Vista Grande Canal Wet Season Monitoring Water Quality Results

Constituent	Units	RL[A]	MDL[A]	BASEFLOW WATER QUALITY RESULTS					INITIAL STORMFLOW EVENT WATER QUALITY RESULTS		STORMFLOW WATER QUALITY RESULTS								POST-STORM WATER QUALITY RESULTS		
				2011-2012 Wet Season Baseflow Sample Date					Initial Stormflow Event: 10/3/11		2011-2012 Wet Season Stormflow Sample Date								LM Wet Season Post Storm Sampling Date (NOTE: No post-storm monitoring for VGC)		
				10/4	1/13	1/24	2/6	2/17	10/3 *3:25pm*	10/3 *5:45pm*	1/20	1/23	2/29	3/13[C]	3/14/2012[D] *Sample 1*	3/14/2012[D] *Sample 2*	Sub-Sample[E] 3/15[C]	3/16[C]	10/4	1/24	3/1
Vista Grande Canal																					
Nutrients																					
Total phosphorous [P]	mg/L	0.04	0.03	-	0.77	0.16	0.34	0.17	1.6 (DF=5)	-	0.62	0.17	0.36	0.18	0.12	0.14	NS	0.15	-	-	-
Orthophosphate as P	mg/L	0.1	0.021	-	0.42	0.14	0.089[J]	0.11	0.56[J] (DF=10)	-	0.27 (DF=2)	0.11	0.13	<0.1	<0.1	0.12	0.12	0.15	-	-	-
Nitrate as N03	mg/L	0.45	0.085	-	22	11	13	20	5.0 (DF=10)	-	5.0 (DF=2)	0.91	1.2	2.6	1.3	1.4	1.4	1.1	-	-	-
Nitrate as N	mg/L	0.1	0.019	-	4.9	2.6	2.8	4.4	1.1 (DF=10)	-	1.1 (DF=2)	0.21	0.26	0.58	0.29	0.32	0.32	0.25	-	-	-
Total Kjeldahl Nitrogen (TKN)	mg/L	0.15	0.07	-	1.6	0.63	1.7	2.8	8	-	4.3	0.68	1.5	0.71	0.43	0.41	NS	0.45	-	-	-
Ammonia as N	mg/L	0.05	0.05	-	0.17	0.19	<0.05	0.064	0.97	-	1.1	<0.05	0.21	0.17	0.09	0.15	NS	0.10	-	-	-
Oxygen Demand																					
Chemical Oxygen Demand (COD)	mg/L	10	10	-	36	12	25	<10	130	-	99	<10	57	37	9.9[J]	9.9[J]	NS	12	-	-	-
Biochemical Oxygen Demand (BOD)	mg/L	4	4	-	4.3	<4	<4	<4	22 (DF=10)	-	29 (DF=5)	<4	9.8	4	<4	<4	NS	<4	-	-	-
Metals (Total)																					
Lead (Pb)	µg/L	0.5	0.1	-	0.86	0.81	2.4	<0.5	70 (DF=20)	-	11 (DF=10)	12	24	5.4	7.9	4.8	3	6.2	-	-	-
Copper (Cu)	µg/L	0.5	0.1	-	9.6	5	7.6	4.9	150 (DF=20)	-	59 (DF=10)	20	35	24	15	14	14	12	-	-	-
Nickel (Ni)	µg/L	0.5	0.1	-	8	6.5	7.6	5.2	37 (DF=20)	-	12 (DF=10)	4.8	7.1	3.6	3.1	3	3.6	3.3	-	-	-
Zinc (Zn)	µg/L	5	1	-	100	27	34	24	960 (DF=20)	-	250 (DF=10)	110	220	100	86	63	67	72	-	-	-
Mercury (Hg)	ng/L	0.5	0.3	-	19	5.1	2.6	1.9	<0.5	-	8.5	15	9.6	6.8	7.3	5.2	NS	8.3	-	-	-
Metals (Dissolved)																					
Lead (Pb) *	µg/L	0.5	0.1	-	0.39[J]	<0.5	<0.5	<0.5	1.6	-	0.85	<0.5	<0.5	0.46[J]	0.28[J]	1.3	0.74	0.54	-	-	-
Copper (Cu)	µg/L	0.5	0.1	-	8.4	4	4.7	3.7	15	-	32	5.3	<0.5	15	6.9	8.5	9.5	5.6	-	-	-
Nickel (Ni)	µg/L	0.5	0.1	-	7.5	5.8	5.5	4.8	12	-	6.1	0.96	<0.5	1.8	1	2.1	1.9	1.1	-	-	-
Zinc (Zn)	µg/L	5	1	-	100	21	8.6	11	110	-	120	29	15	68	35	45	56	46	-	-	-
Physical Parameters																					
Total Suspended solids (TSS)	mg/L	1	-	3.5	9.2 (DF=2)	2.4 (DF=2)	19.2 (DF=2)	3 (DF=2)	445 (DF=10)	22.6 (DF=2)	119 (DF=5)	48.4 (DF=2)	103 (DF=2)	24.4 (DF=2)	19.2	11.9	4.2	18.8 (DF=2)	-	-	-
Volatile Suspended Solids (VSS)*	mg/L	4	-	<4	<4	<4	9	<4	135	10.6	45	14	36.8	10.2	8	5	NS	11	-	-	-
Total Dissolved Solids (TDS)	mg/L	10	-	-	405	248	450	448	206	-	144	31	48	100	53	75	NS	70	-	-	-
Hardness	mg CaCO3/L	1	-	-	250	160	260	250	85	-	45	14	19	25	18	19	NS	16	-	-	-
Bacteria/ Organisms																					
Total Coliform	cfu/100 mL	-	-	3,100,000	12,200	<100	17,200	6,600	9,700,000	1,100,000	520,000	20,000	100,000	400,000	400,000	40,000	10,000	NS	-	-	-
Fecal Coliform	cfu/100 mL	-	-	19,000	2,600	<10	50	120	41,000	74,000	4,800	7,200	2,000	8,000	8,000	3,000	5,000	NS	-	-	-
E. coli	cfu/100 mL	-	-	<10,000	600	<100	200	1,000	300,000	400,000	200,000	20,000	<10,000	10,000	<10,000	<10,000	10,000	NS	-	-	-
Enterococcus	cfu/100 mL	-	-	16,000	350	<10	70	570	120,000	36,000	42,000	11,000	25,000	18,000	18,000	7,000	4,000	NS	-	-	-
MS-2 (Bacteriophage, Male Specific)	pfu/mL	-	-	184	12	NS	<1	27	75	220	28	47	21	4	4	12	52	NS	-	-	-
Giardia	cysts/L	-	-	1.2	0.23	NS	<0.13	<0.13	<0.5	NS	NS	<0.12	<0.12	NS	NS	NS	<0.12	NS	-	-	-
Cryptosporidium spp.	oocysts/L	-	-	<0.1	<0.12	NS	<0.13	<0.13	<0.5	NS	NS	<0.12	<0.12	NS	NS	NS	<0.12	NS	-	-	-
Bacteroidales - General		-	-	Present	Present	NS	Present	Present	Present	Present	Present	Present	Present	NS	Present	Present	Present	NS	-	-	-
Bacteroidales - Human		-	-	Present	Present	NS	Present	Present	ND	ND	Present	Present	ND	NS	Present	Present	Present	NS	-	-	-

NOTES:

[a] Reporting Limits (RLs) and Method Detection Limits (MDLs) are based on a Dilution Factor of 1 (DF=1).
Reporting Limit (RL) corresponds to the lowest amount of an analyte in a sample that can be quantitatively determined with acceptable precision and accuracy by the laboratory.
The Method Detection Limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

[B] Chlorophyll a is only relevant to Lake Merced (LM); not relevant to VGC.

[C] The storm event on 3/13/12 was a multi-day storm event. Multiple peak flows were documented and sampled within the Canal between 3/13/12 and 3/16/12. However, concurrent storm sampling was conducted in Lake Merced only during the 3/14/12 storm sample event.

[D] The storm event on 3/14/12 exceeded the capacity of the auto-sampler. Sample 1 represents a composite sample collected for the rising limb of the hydrograph and Sample 2 represents a composit sample for the falling limb of the hydrograph (see Figure 3-9).

[E] Due to a short duration flow event, only a small volume of stormwater was collected via the autosampler on 3/15/12. As a result, insufficient sample volume was available for analysis of the full suite of constituents. For this reason, only priority constituents were analyzed and reported.

[F] Chlorophyll a sample for 3/14/12 lost in transit

< Not detected or are present below the reporting limits.

[J] Analyte detected below Reporting Limit (RL) but above Method Detection Limit (MDL) and therefore the reported concentration is qualified as estimated and not considered quantified.

* There are less than 6 dry season samples for this constituent.

DF= Sample has a dilution factor higher than 1. The sample result must be increased by a factor corresponding to the dilution factor.

ND represents a non-detect result from laboratory analysis.

NS/- represents a constituent for which no sample was collected or a day where no sampling occurred.

Lake Merced Wet Season Monitoring Water Quality Results

Constituent	Units	RL[A]	MDL[A]	BASEFLOW WATER QUALITY RESULTS					INITIAL STORMFLOW EVENT WATER QUALITY RESULTS		STORMFLOW WATER QUALITY RESULTS								POST-STORM WATER QUALITY RESULTS		
				2011-2012 Wet Season Baseflow Sample Date					Initial Stormflow Event: 10/3/11		2011-2012 Wet Season Stormflow Sample Date								LM Wet Season Post Storm Sampling Date (NOTE: No post-storm monitoring for VGC)		
				10/4	1/13	1/24	2/6	2/17	10/3	10/3	1/20	1/23	2/29	3/13[C]	3/14/2012[D]		Sub-Sample[E]	3/16[C]	10/4	1/24	3/1
									3:25pm	5:45pm					Sample 1	Sample 2	3/15[C]				
Lake Merced																					
Nutrients																					
Total phosphorous [P]	mg/L	0.04	0.03	-	0.14	-	0.13	0.1	0.17		0.15	0.14	0.11	-	0.10		-	-	-	-	-
Orthophosphate as P	mg/L	0.1	0.021	-	0.075[J]	-	<0.1	<0.1	0.039[J]		<0.1	0.073[J]	<0.1	-	<0.1		-	-	-	-	-
Nitrate as N03	mg/L	0.45	0.085	-	0.32[J]	-	0.20[J]	<0.45	0.13[J]		<0.45	0.31[J]	<0.45	-	0.44[J]		-	-	-	-	-
Nitrate as N	mg/L	0.1	0.019	-	0.072[J]	-	0.045[J]	<0.1	0.03[J]		<0.1	0.07[J]	<0.1	-	0.099[J]		-	-	-	-	-
Total Kjeldahl Nitrogen (TKN)	mg/L	0.15	0.07	-	1.4	-	1	1	1.9		1.3	0.98	1	-	0.6		-	-	-	-	-
Ammonia as N	mg/L	0.05	0.05	-	<0.05	-	<0.05	0.14	<0.05		<0.05	<0.05	<0.05	-	0.03[J]		-	-	-	-	-
Chlorophyll a [B]	µg/L	5	5	-	45	-	<5	29	67		<5.0	35	22	-	NS[F]		-	-	-	-	-
Oxygen Demand																					
Chemical Oxygen Demand (COD)	mg/L	10	10	-	21	-	57	<10	42		15	25	<10	-	20		-	-	-	-	-
Biochemical Oxygen Demand (BOD)	mg/L	4	4	-	<4	-	<4	<4	<4		<4	<4	<4	-	<4		-	-	-	-	-
Metals (Total)																					
Lead (Pb)	µg/L	0.5	0.1	-		-	0.30[J]	<0.5	<0.5		0.33[J]	0.74	<0.5	-	0.62		-	-	-	-	-
Copper (Cu)	µg/L	0.5	0.1	-	0.48[J]	-	0.52	5.2	<0.5		1.2	0.69	<0.5	-	<0.5		-	-	-	-	-
Nickel (Ni)	µg/L	0.5	0.1	-	0.33[J]	-	<0.5	<0.5	<0.5		0.47[J]	<0.5	<0.5	-	0.2[J]		-	-	-	-	-
Zinc (Zn)	µg/L	5	1	-	4.1[J]	-	1.0[J]	<5	4.2[J]		4.6[J]	<5	<5	-	1.8[J]		-	-	-	-	-
Mercury (Hg)	ng/L	0.5	0.3	-	<0.5	-	0.5	<0.5	<0.5		<0.5	<0.5	<0.5	-	<0.5		-	-	-	-	-
Metals (Dissolved)																					
Lead (Pb) *	µg/L	0.5	0.1	-	<0.5	-	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	-	<0.5		-	-	-	-	-
Copper (Cu)	µg/L	0.5	0.1	-	<0.5	-	0.14[J]	<0.5	<0.5		0.46[J]	<0.5	6.3	-	<0.5		-	-	-	-	-
Nickel (Ni)	µg/L	0.5	0.1	-	0.15[J]	-	<0.5	<0.5	<0.5		<0.5	<0.5	1.1	-	0.14[J]		-	-	-	-	-
Zinc (Zn)	µg/L	5	1	-	19	-	<5	12	<5		<5	<5	54	-	24		-	-	-	-	-
Physical Parameters																					
Total Suspended solids (TSS)	mg/L	1	-	-	9.8 (DF=2)	-	12 (DF=2)	10.4 (DF=2)	15 (DF=2)		8.8 (DF=2)	11.4 (DF=2)	9.5	-	8		-	-	-	-	-
Volatile Suspended Solids (VSS)*	mg/L	4	-	-	9.4	-	12.6	10.2	14.8		9.6	11.4	9.8	-	7.6		-	-	-	-	-
Total Dissolved Solids (TDS)	mg/L	10	-	-	466	-	402	423	427		418	311	392	-	427		-	-	-	-	-
Hardness	mg CaCO3/L	1	-	-	220	-	220	210	220		210	220	210	-	220 (DF=10)		-	-	-	-	-
Bacteria/ Organisms																					
Total Coliform	cfu/100 mL	-	-	-	43	-	397	618	40		500	100	<100	-	100		-	-	40	41	890
Fecal Coliform	cfu/100 mL	-	-	-	35	-	49	38	60		80	80	30	-	10		-	-	60	26	1,400
E. coli	cfu/100 mL	-	-	-	34	-	30	50	20		300	100	<100	-	<100		-	-	20	20	110
Enterococcus	cfu/100 mL	-	-	-	58	-	25	18	30		120	330	10	-	50		-	-	20	27	1,960
MS-2 (Bacteriophage, Male Specific)	pfu/mL	-	-	-	<1	-	131	1	<1		9	2	2	-	<1		-	-	<1	NS	NS
Giardia	cysts/L	-	-	-	<0.12	-	<0.14	<0.12	<0.1		NS	<0.14	<0.12	-	<0.12		-	-	<0.24	NS	NS
Cryptosporidium spp.	oocysts/L	-	-	-	<0.12	-	<0.14	<0.12	<0.1		NS	<0.14	<0.12	-	<0.12		-	-	<0.24	NS	NS
Bacteroidales - General		-	-	-	Present	-	Present	Present	Present		Present	Present	Present	-	Present		-	-	Present	NS	NS
Bacteroidales - Human		-	-	-	Absent LM4	-	ND	ND	ND		ND	ND	ND	-	ND		-	-	ND	NS	NS

NOTES:

[a] Reporting Limits (RLs) and Method Detection Limits (MDLs) are based on a Dilution Factor of 1 (DF=1).
Reporting Limit (RL) corresponds to the lowest amount of an analyte in a sample that can be quantitatively determined with acceptable precision and accuracy by the laboratory.
The Method Detection Limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

[B] Chlorophyll a is only relevant to Lake Merced (LM); not relevant to VGC.

[C] The storm event on 3/13/12 was a multi-day storm event. Multiple peak flows were documented and sampled within the Canal between 3/13/12 and 3/16/12. However, concurrent storm sampling was conducted in Lake Merced only during the 3/14/12 storm sample event.

[D] The storm event on 3/14/12 exceeded the capacity of the auto-sampler. Sample 1 represents a composite sample collected for the rising limb of the hydrograph and Sample 2 represents a composit sample for the falling limb of the hydrograph (see Figure 3-9).

[E] Due to a short duration flow event, only a small volume of stormwater was collected via the autosampler on 3/15/12. As a result, insufficient sample volume was available for analysis of the full suite of constituents. For this reason, only priority constituents were analyzed and reported.

[F] Chlorophyll a sample for 3/14/12 lost in transit

< Not detected or are present below the reporting limits.

[J] Analyte detected below Reporting Limit (RL) but above Method Detection Limit (MDL) and therefore the reported concentration is qualified as estimated and not considered quantified.

* There are less than 6 dry season samples for this constituent.

DF= Sample has a dilution factor higher than 1. The sample result must be increased by a factor corresponding to the dilution factor.

ND represents a non-detect result from laboratory analysis.

NS/- represents a constituent for which no sample was collected or a day where no sampling occurred.

Preliminary Water Quality Screening Results 2003/04 – 2008/09 Wet Weather Seasons
Lake Merced Pilot Stormwater Enhancement Project

Prepared for the North San Mateo County Sanitation District
by EOA, Inc.
with Assistance from the San Francisco Public Utilities Commission (June 2011)

The City of Daly City and the San Francisco Public Utilities Commission (SFPUC) established a collaborative effort referred to as the Lake Merced Pilot Stormwater Enhancement Project. The study performed pilot fieldwork in support of assessing the feasibility of diverting stormwater runoff from the Vista Grande drainage basin in Daly City into South Lake Merced in San Francisco. The stormwater runoff was treated by a Continuous Deflection System (CDS) and a riparian buffer along the southwestern shoreline of South Lake Merced before conveyance to the Lake.

Bacteriological water quality monitoring data were collected of CDS and riparian buffer treated Vista Grande Canal stormwater at six near-shore and one background station in South Lake Merced during six consecutive wet seasons (2003/04 through 2008/09). Lake water sample data were evaluated for 17 rainstorms with pilot diversions. The monitoring program was designed to screen for selected potential water quality impacts associated with the pilot diversions. The primary objective was to determine whether the diversion of limited volumes of treated stormwater (about 0.1 to 5.4 million gallons per storm event) increased concentrations of bacterial indicators of human fecal contamination in South Lake Merced, potentially indicating increased human health risk during permitted water contact recreation activities (boating, fishing) in and adjacent to the lake. Full body contact recreation (swimming, wading) in the Lake is prohibited by SFPUC since the Lake serves as an emergency water supply for sanitation and fire-fighting purposes.

Concentrations of E. coli, USEPA's recommended bacterial indicator for fresh water, and of Enterococcus and alternative indicator, were typically reduced by approximately 99% as measured near-shore (station LM-1) in the Lake and at the background reference station (SFPUC Pistol Range site (LM-PR)), compared to the bacterial concentrations in the CDS treated Canal stormwater. These bacterial indicator data collected typically 48 to 72 hours after cessation of stormwater diversions, in combination with a low probability of human exposure, suggested a low probability of increased human health risk during that time period.

Vista Grande Canal Pilot Stormwater Diversion Project 2004-2009
VGC Canal After CDS Treatment and Subsequent Lake Merced Bacteriological Concentrations

Sample Station	Date Collected	Resampling Interval (hours)	*E. coli* (MPN/100mL)	Percent Decrease E. Coli	Enterococci (MPN/100mL)	Percent Decrease Enterococci	Rainfall (inches)	Volume Diverted (gal)
LM-CDS	12/08/04	24	13,500	-	10,500	-	3.11	109,200
LM-PR	12/09/04		300	97.8%	< 100	> 99.0%		
LM-1	12/09/04		100	99.3%	100	99.0%		
LM-CDS	01/07/05	72	4,710	-	28,200	-	1.68	3,249,000
LM-PR	01/10/05		63	98.7%	< 10	> 99.9%		
LM-1	01/10/05		20	99.6%	10	99.9%		
LM-CDS	02/14/05	72	2,090	-	740	-	2.27	2,653,900
LM-PR	02/17/05		41	98.0%	10	98.6%		
LM-1	02/17/05		41	98.0%	20	97.3%		
LM-CDS	03/22/05	48	9,900	-	4,740	-	1.72	563,700
LM-PR	03/24/05		62	99.4%	< 10	> 99.8%		
LM-1	03/24/05		41	99.6%	< 10	> 99.8%		
LM-CDS	02/27/06	48	15,531	-	9,804	-	1.9	868,700
LM-PR	03/01/06		< 10	> 99.9%	10	99.9%		
LM-1	03/01/06		20	99.9%	< 10	> 99.9%		
LM-CDS	03/06/06	72	> 24,192	-	8,664	-	0.77	475,100
LM-PR	NS		-	-	-	-		
LM-1	03/09/06		135	> 99.4%	< 10	> 99.9%		
LM-CDS	03/20/06	48	7,270	-	2,098	-	0.45	854,700
LM-PR	03/22/06		10	99.9%	< 10	> 99.5%		
LM-1	NS		-	-	-	-		
LM-CDS	03/27/06	48	3,255	-	2,909	-	0.6	961,900
LM-PR	03/29/06		41	98.7%	< 10	> 99.7%		
LM-1	03/29/06		20	99.4%	< 10	> 99.7%		
LM-CDS	03/31/06	72	4,106	-	5,012	-	1.4	2,646,100
LM-PR	04/03/06		< 10	> 99.8%	< 10	> 99.8%		
LM-1	04/03/06		450	89.0%	502	90.0%		
LM-PR	04/05/06	120	10	99.8%	< 10	> 99.8%	-	-
LM-1	04/05/06		63	98%	< 10	> 99.8%		
LM-CDS	04/11/06	48	7,270	-	3,282	-	1.59	1,358,400
LM-PR	04/13/06		10	99.9%	< 10	> 99.7%		
LM-1	04/13/06		10	99.9%	10	99.7%		
LM-CDS	2/26/07	72	3873	-	2,247	-	NA	728,382
LM-PR	NS		-	-	-	-		
LM-1	3/1/07		41	98.9%	< 10	> 99.6%		
LM-PR	NS	-	-	-	-	-	-	-
LM-1	3/2/07		10	99.7%	< 10	> 99.6%		

Vista Grande Canal Pilot Stormwater Diversion Project 2004-2009
VGC Canal After CDS Treatment and Subsequent Lake Merced Bacteriological Concentrations

Sample Station	Date Collected	Resampling Interval (hours)	*E. coli* (MPN/100mL)	Percent Decrease E. Coli	Enterococci (MPN/100mL)	Percent Decrease Enterococci	Rainfall (inches)	Volume Diverted (gal)
LM-CDS	03/26/07	48	11,199	-	8,164	-	NA	572,236
LM-PR	03/28/07		20	99.8%	< 10	> 99.9%		
LM-1	03/28/07		134	98.8%	< 10	> 99.9%		
LM-PR	03/29/07	72	20	99.8%	< 10	> 99.9%	-	-
LM-1	03/29/07		84	99.2%	< 10	> 99.9%		
LM-CDS	04/11/07	24	8,164	-	4,884	-	NA	86,931
LM-PR	04/12/07		20	99.8%	< 10	> 99.8%		
LM-1	04/12/07		51	99.4%	< 10	> 99.8%		
LM-PR	04/13/07	48	10	99.9%	< 10	> 99.8%	-	-
LM-1	04/13/07		< 10	> 99.9%	< 10	> 99.8%		
LM-CDS	12/18/07	48	1,956	-	3,255	-	NA	Unavailable
LM-PR	12/20/07		86	95.6%	10	99.7%		Meter Broken
LM-1	12/20/07		581	70.3%	794	75.6%		
LM-PR	12/21/07	72	83	95.8%	31	99.0%	-	-
LM-1	12/21/07		41	97.9%	10	99.7%		
LM-CDS	01/22/09	96	4,106		3873		NA	317,881
LM-PR	01/26/09		10	99.8%	< 10	> 99.7%		
LM-1	01/26/09		10	100%	10	99.7%		
LM-PR	01/27/09	120	< 10	> 99.8%	10	99.7%		
LM-1	01/27/09		10	99.8%	< 10	> 99.7%		
LM-CDS	02/13/09	96	< 10	-	< 10	> -	NA	5,408,694
LM-PR	02/17/09		20	0%	10	0%		
LM-1	02/17/09		292	0%	345	0%		
LM-PR	02/18/09	120	10	0%	< 10	> 0%	-	-
LM-1	02/18/09		75	0%	< 10	> 0%		

NA = Not Available
NS = Not Sampeld

LM-CDS = Vista Grande Canal runoff after Continuous Deflection System treatment
LM-PR = Lake Merced background water quality station
LM-1 = Lake Merced nearfield monitoring station

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APPENDIX C

Lake Filling Scenarios

Contents:

Lake filling scenario hydrologic summaries by target water surface elevation scenario

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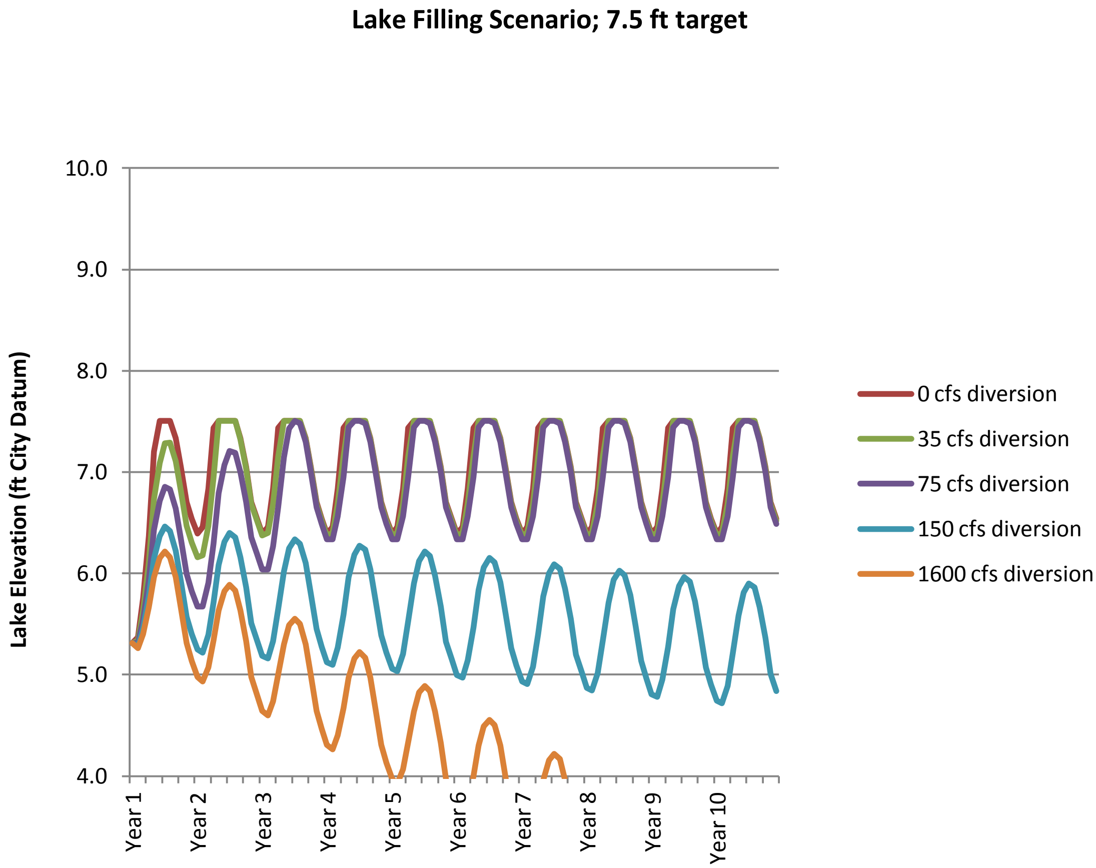
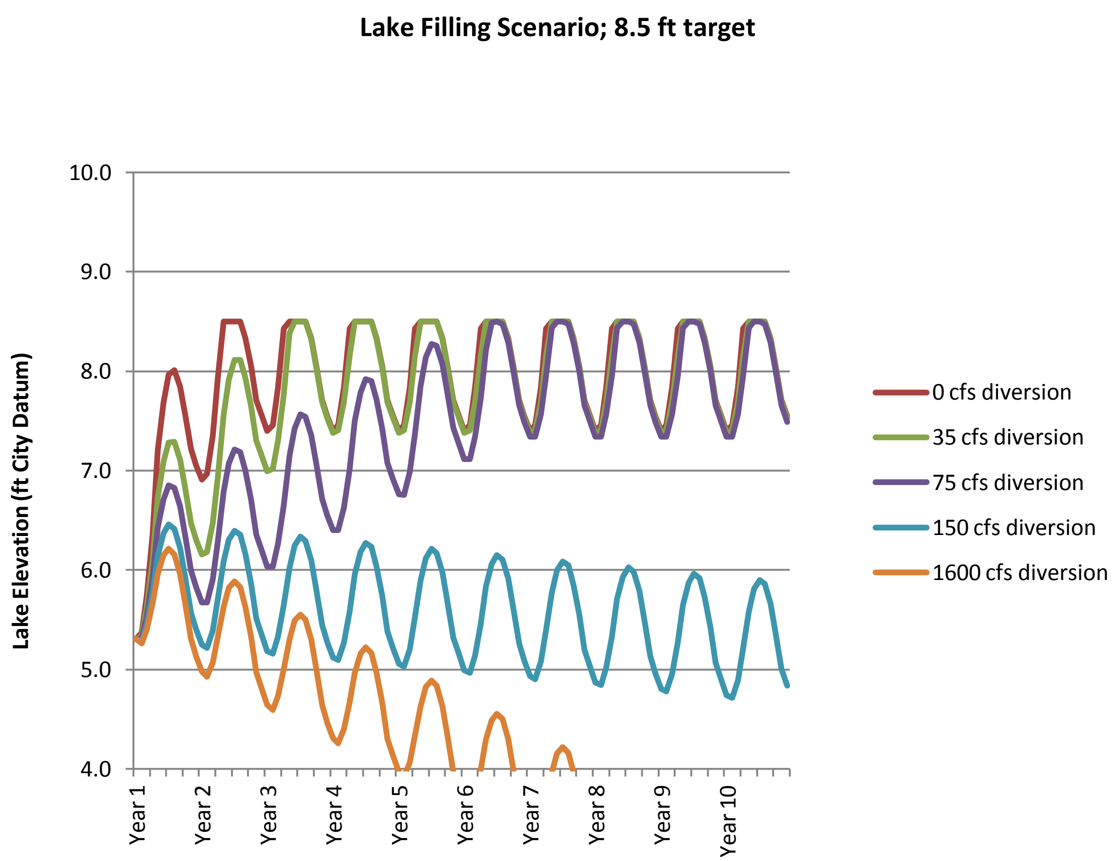
Target elevation = 7.5 feet City Datum

Diversion Scenario	Time until target elevation reached	Wetland contribution until target reached		Vista Grande Canal contribution until target reached	
(cfs)	*(months)*	*(acre-feet)*	*(ac-ft/year)*	*(acre-feet)*	*(ac-ft/year)*
0	6	146	291	529	1058
35	17	404	285	629	444
75	31	725	281	611	236
150	--	146	--	--	--
1600	--	146	--	--	--



Target elevation = 8.5 feet City Datum

Diversion Scenario	Time until target elevation reached	Wetland contribution until target reached		Vista Grande Canal contribution until target reached	
(cfs)	*(months)*	*(acre-feet)*	*(ac-ft/year)*	*(acre-feet)*	*(ac-ft/year)*
0	17	404	285	1033	729
35	30	699	280	1017	407
75	67	1554	278	1225	219
150	--	--	--	--	--
1600	--	--	--	--	--



APPENDIX D

1997 to 2009 South Lake Monitoring Data Summary

Contents:

Lake Merced Water Quality Data Organization, Review and Analysis, Kennedy/Jenks Consultants, 2010

Additional box plots of 1997 to 2009 data

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Lake Merced Water Quality Data Organization, Review and Analysis

25 January 2010

Prepared for

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1145 Market Street, 4th Floor
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K/J Project No. 0968009*00

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Executive Summary

Lake Merced, a freshwater lake located in southwestern San Francisco, is a natural habitat for many species of birds and waterfowl and a regional recreational venue offering fishing, boating, bicycling, and wildlife viewing. The San Francisco Recreation and Park Department maintains the perimeter lands for recreational uses. The San Francisco Public Utilities Commission considers Lake Merced as an emergency non-potable water supply. Water quality data have been collected since 1997 by the SFPUC. From 1997 to 2005, relatively large volumes of SFPUC water were added to the Lake to raise and maintain water levels. Kennedy/Jenks Consultants was contracted to review, organize, and interpret the water quality data. The purpose of this report is to review the water quality data gathered from 1997 to 2009; determine if the "health" of Lake Merced has improved, remained constant, or has degraded; and determine if the current water quality monitoring program is accurately capturing the water quality of Lake Merced and provide recommendations accordingly.

Based on a review of the data through 2008, seven water quality parameters were chosen to represent lake health. These seven parameters are presented in four groups:

- **Dissolved oxygen (DO):** Sufficient oxygen dissolved in the water is vital for fish habitat and for biological processes to maintain lake health.
- **Secchi depth:** Secchi depth is a measurement indicating lake clarity. For Lake Merced, greater Secchi depths are desirable. The Secchi depth can be affected by algae production or unrelated suspended solids.
- **Algae, Total Phosphorus, Total Nitrogen, and Nitrogen to Phosphorus ratio (N:P):** The importance of the algae concentrations and the N:P ratio is these parameters indicate algal production and the limiting macro-nutrient. Algae production, nutrient load and their interrelationship are driving factors affecting long term lake health.
- **Total Coliform and *Escherichia coli* (E. coli):** Total Coliform and E. coli are indicators of pathogenic microorganisms and fecal contamination.

After a review of these water quality parameters, it appears that the health of Lake Merced has remained relatively constant from 1997 to 2008 although a slight, yet statistically significant, increase in lake clarity (Secchi depth) has been observed. Lake water quality has been slightly affected by large additions of water but these events have not changed observed trends in Lake health indicators.

Dissolved oxygen remains above the warm (5 mg/L) and cold (7 mg/L) water habitat criteria for the majority of the data set but there have been episodes of DO lower than 5 mg/L. Lake Merced is considered a weakly and intermittent stratified lake and the data indicate that significant additions of nutrients due to low DO and internal nutrient cycling does not occur.

From 2001 to 2005, the Lake appeared to be phosphorous-limited or nitrogen and phosphorous co-limited. In 2005, near the time of a large unplanned water addition, the lake shifted to being nitrogen limited. Large additions of the limiting nutrient into the Lake can cause the proliferation of algae. During the sampling period, there have been no significant changes in algal biomass levels, with periodic increases in concentration due to algae blooms.

The California Department of Public Health provides the threshold guidelines for recreational waters for the protection of public health: 10,000 per 100 mL total coliform and 235 per 100 mL for E. coli. The total coliform and E. Coli levels in Lake Merced have been usually well below these thresholds.

The sampling and analysis protocol for Lake Merced is similar to protocols for drinking water reservoirs managed by SFPUC. As the use of Lake Merced is different than a drinking water reservoir, recommendations were made to alter the sampling details to focus on important, varying water quality parameters and minimize the collection of data that is less useful to the SFPUC. The recommendations to the sampling and analysis are listed in Table ES-1.

Table ES-1: Lake Merced Monitoring Recommendations

Constituent	Current Sampling Location	Current Sampling Frequency	Current Sampling Depth	Recommended Sampling Location	Recommended Sampling Frequency	Recommended Sampling Depth
Algal Biomass	4	Q	2	4	Q	2
Alkalinity	4	Q	M	4	A	M
Ammonium (NH_4^+)	4	Q	M	4	Q	M
Bromide (Br^-)	4	Q	M		None	
Chloride (Cl^-)	4	Q	M	4	A	S
Chlorophyll	4	Q	2	4	Q	2
Conductivity	4	Q	M	4	Q	M
Dissolved oxygen (DO)	4	Q	M	4	Q	M[1]
E.coli	4	Q	1	4	Q	1
Fluoride (Fl^-)	4	Q	M	4	A	S
Hardness	4	Q	M	4	A	S
Iron (Fe)	4	Q	M	4	Q	S-B
Lead (Pb)	4	Q	2	4	Q	2
Manganese (Mn)	4	Q	M	4	Q	S-B
MTBE	4	Q	M	4	A	S
Nitrate (NO_3^-)	4	Q	M	4	Q	M
Orthophosphate	4	Q	M	4	Q	M
Oxidation-reduction potential (ORP)	4	Q	M	4	Q	M[1]
pH	4	Q	M	4	Q	M[1]
Plankton	4	Q	1	4	Q	1
Secchi depth	4	Q	N/A	4	Q	N/A
Sulfate (SO_4^{2-})	4	Q	M		None	
Temperature	4	Q	M	4	Q	M
Total Coliform	4	Q	1	4	Q	1
Total dissolved solids (TDS)	4	Q	M	4	A	M
Total Kjeldahl nitrogen (TKN)	4	Q	M	4	Q	M
Total organic carbon (TOC)	4	Q	M	4	Q	S
Total phosphorus	4	Q	M	4	Q	M
Turbidity	4	Q	M	4	Q	M

4 – current four locations: Lake Merced North, Lake Merced North East, Lake Merced South- Pistol Range, Lake Merced South- Pump Station
Q – quarterly
2 – currently sampled at two depths
M – multiple depths
A – annual
None – discontinue sampling
S – surface only
1 – currently sampled at one depth or through the water column
S-B – surface and near bottom
[1] – note time of day

Section 1: Introduction

Lake Merced is a freshwater lake located in southwestern San Francisco, bounded by Skyline Boulevard, Lake Merced Boulevard, and John Muir Boulevard (Figure 1) approximately 0.25 miles east of the Pacific Ocean. Lake Merced is a natural habitat for many species of birds and waterfowl and a regional recreational venue offering fishing, boating, bicycling, and wildlife viewing.

Prior to the beginning of Hetch-Hetchy aqueduct water delivery in 1935, Lake Merced was used as a municipal water supply. When San Francisco began receiving Hetch-Hetchy water, Lake Merced became an emergency and irrigation water supply source. In the late 1930s, the City of San Francisco (City) acquired Lake Merced and gave jurisdiction of the Lake to the SFPUC. In 1950, the jurisdiction of the Lake was given to San Francisco Recreation and Park District to develop beneficial recreational uses at the Lake while maintaining its status as an emergency water supply.

Beginning in the late 1980s, Lake Merced's water levels began declining. By the early 1990s, water levels had dropped ten feet below the historic averages of the 1950s to 1980s. Declining water levels generated significant concern over the long-term health of Lake Merced for recreational, ecological, and emergency water supply uses and a stakeholder-led effort to develop a long-term lake level management plan was initiated.

In 2006, Lake Merced water levels reached 6.8 feet City Datum, a level not reached for 20 years. Lake level increases from 2002 to 2006 are a result of a combination of factors, including above-average precipitation, reductions in groundwater pumping, SFPUC system water additions in 2002 and 2003, and limited addition of treated stormwater from 2004 to 2006 as part of the Lake Merced Pilot Stormwater Enhancement Project (EOA 2007).

Regular detailed water quality monitoring has occurred at Lake Merced since 1997. There has been no documented interpretation of those data since 2005. Lake Merced is considered a shallow eutrophic lake that is on the California 303 (d) list for pH and dissolved oxygen. The Water Resources Division at the SFPUC believes the water quality has not significantly changed since regular monitoring began in 1997. The SFPUC maintains the collected water quality data in a series of Microsoft Excel workbooks. Kennedy/Jenks Consultants has been contracted to review, organize, and interpret collected Lake Merced water quality data. This Technical Memorandum fulfills the scope of services associated with that contract.

1.1 Project Objectives

The objectives of this work are:

- Determine if the water quality of Lake Merced has remained the same, has been enhanced or has been degraded from 1997 to 2008. This includes identifying at least three "lake health" indicators from the available data set and presenting the trending of these parameter values in South Lake over time; and

- Determine if current water quality monitoring is accurately capturing the water quality of Lake Merced (including water quality parameters measured, frequency and location of sampling, analytical methods used, etc.)

- Determine what data trends (i.e., graphs and tables) best allow Water Resources staff to monitor the water quality of Lake Merced in a fast, efficient manner.

To complete these objectives, Kennedy/Jenks Consultants electronically received water quality data from the Water Resources group in Microsoft Excel™ format and organized the data to permit analysis.

Section 2: Current Lake Merced Monitoring Program and Data

Current monitoring of Lake Merced water quality began in 1997 by the Environmental Services section of the Water Quality Bureau and more recently the Limnology section of the Natural Resources Bureau has continued this monitoring on a quarterly basis. The monitoring program is similar to monitoring programs at SFPUC drinking source water reservoirs and is conducted by the same department at SFPUC.   Sampling occurs between 3 and 8 times per year, but is typically conducted quarterly. Samples are taken at 4 locations: North Lake, East Lake, South Lake near the Pump Station, and South Lake near the police Pistol Range (Figure 1). For the majority of parameters, samples at each location were taken at various depths, often starting at the surface and decreasing at 5-foot intervals until the bottom of the Lake.

SFPUC Water Resources staff indicated at an August 6, 2008 meeting with the Natural Resources Division staff that:

> *"…SFPUC and SFPUC staff would like to maintain Lake Merced as an untreated, emergency supply; promote a healthy put and take fishery; continue and maintain a non-contact recreation water body; and raise lake levels. SFPUC staff would like to create an environment that people will enjoy and maintain a commitment to public health and safety."*

Considering this meeting, the review of water quality and lake health is based on these uses and goals.

Table 1 lists the parameters that were measured in Lake Merced from May 1997 to December 2008 and statistical analysis for each parameter. The number of sampling events (n) is listed for each constituent. Sampling events occur at four locations and can comprise as many as six different depth samples per location. This has resulted in a large data set that includes 1,100 data points for most constituents and approximately 30,000 total data points.

Some data sets have "less than" values indicating analytical results below minimum reporting limits. For example, the first two years of nitrate data indicate values of "<0.09." This report uses half of the reported less-than value (e.g., 0.045 for "<0.09") to calculate statistical parameters presented.

Table 1: Water Quality Parameters measured in Lake Merced (South Lake Pump Station)

N	Constituent	Units	Average	Median	Range	Standard Deviation	Coefficient of Variance
47	Algal Biomass	ug/L	1,891	1,588	402-6,705	1,078	0.57
55	Alkalinity	mg/L	172	170	136-230	19.2	0.11
55	Ammonium (NH_4^+)	mg/L	0.06	0.04	ND-0.65	0.07	1.24
4	Bromide (Br^-)[1]	mg/L	0.28	0.26	0.22-0.34	0.04	0.15
55	Chloride (Cl^-)	mg/L	75	73	58-98	8.8	0.12
55	Chlorophyll	ug/L	27	23	4.7-100	16	0.58
55	Conductivity[2]	mmho/cm	580	593	431-715	63.3	0.11
54	Dissolved oxygen (DO)[2]	mg/L	7.1	7.7	0.1-12.2	2.7	0.38
53	E.Coli	MPN/100 ml	36.9	26.0	2.0-100	30.4	0.82
55	Fluoride (Fl^-)	mg/L	0.39	0.38	0.22-0.68	0.09	0.22
55	Hardness	mg/L	180	176	140-230	17.8	0.10
55	Iron (Fe)	mg/L	0.026	ND	ND-0.14	0.031	1.21
10	Lead (Pb)	ug/L	0.42	ND	0.03-0.81	0.21	0.50
55	Manganese (Mn)	mg/L	0.06	0.04	0.02-0.3	0.05	0.76
54	MTBE[3]	ug/L	0.33	ND	ND-1.9	0.27	0.82
55	Nitrate (NO_3^-)	mg/L	0.033	ND	ND-0.62	0.09	2.77
55	Orthophosphate	mg/L	0.06	0.04	ND-0.2	0.05	0.88
55	Oxidation-reduction potential (ORP)[2]	mV	319	318	29-543	105	0.33
55	pH[2]	-	8.1	8.1	6.8-8.8	0.35	0.04
53	Plankton	NU/mL	823	850	17-2,511	477	0.58
55	Secchi depth[2]	Feet	1.8	1.7	1.0-3.0	0.50	0.28
4	Sulfate (SO_4^{2-})[1]	mg/L	10.3	9.3	6.5-16	3.75	0.36
55	Temperature[2]	^oC	15.8	16.3	9.8-22	3.0	0.19
53	Total Coliform	MPN/100 ml	973	841	109-2420	676	0.69
55	Total dissolved solids (TDS)	mg/L	372	380	276-458	40.7	0.11
55	Total Kjeldahl nitrogen (TKN)	mg/L	3.76	2.39	ND-28.2	3.81	1.01
55	Total organic carbon (TOC)	mg/L	6.70	6.20	ND-16.4	2.33	0.35
55	Total phosphorus	mg/L	0.15	0.15	ND-0.26	0.06	0.39
55	Turbidity	NTU	13.2	11.8	2.5-33	5.4	0.41

[1] Not enough data to track variability over time.
[2] Field measured data.
[3] ND since 2003.

2.1 Statistical Analysis

Increasing or decreasing trends in certain water quality constituents can be used as indicators of water quality conditions. A trend in water quality is a change over time in the chemical, physical, or biological characteristics of the water; in this report, it is defined as a one-directional change over time. An analysis was conducted using the complete data set over the past 12 years. The Pump Station and Pistol Range locations in South Lake were selected as representative sample points and the data from these sampling points will be presented in this report.

First, a standard linear regression was applied to the constituents listed in Table 2 to identify any distinct trends. Although many showed visual trends, only certain constituents exhibited statistically significant linear trends. Because the values of water quality parameters often vary seasonally, an additional trend statistic known as a Seasonal Kendall test was run on the data. Trend analysis using the Seasonal Kendall test for surface water quality has been used by Trench (1996), Neitzert (2003), Hirsh et al. (1991), Ragavan and Hernandez (2006), and on many different systems (Ryberg & Vecchia, 2003).

The Seasonal Kendall test is a Mann-Kendall test (a non-parametric test that evaluates long-term trends) that takes into consideration the variability due to seasonal effects, such as air temperature and daylight. A season can be defined as any timeframe and in this report, the data have been categorized into six, two-month seasons: January/February, March/April, etc. The Seasonal Kendall test accounts for seasonality by computing the Mann-Kendall test of each season separately and then combining the results. Therefore, January/February data are compared only to other January/February data, March/April only with March/April, etc.

The Seasonal Kendall test uses two parameters, the S-value and the p-value, to determine trending and significance. A positive S-value indicates an increasing trend in the data, while a decreasing trend has a negative S-value. The farther from zero the S-value is, the greater the trend. Additionally, a trend is considered significant if the p-value level is less than or equal to 0.10. A smaller p-value indicates a more significant trend.

A Seasonal Kendall test was run for the South Lake Pump Station and Pistol Range locations at depths of 0 feet (surface), 5 feet, 10 feet, and 15 feet. Table 2 shows the statistical results for both sampling locations in South Lake and only reports results when the measured trend applies across all depths.

Table 2: Statistical Results of Water Quality Constituents

	Pistol Range		South Pump Station		
Constituent	**Significant linear trend**	**Significant Seasonal Kendall**	**Significant linear trend**	**Significant Seasonal Kendall**	**% Change in Linear Regression**
Algae				Increase	-14%
Alkalinity	Decrease	Decrease	Decrease	Decrease	-10%
Chloride	Increase	Increase	Increase	Increase	+23%
DO	Increase				+2.3%
Fe	Decrease				-18%
Fluoride	Increase		Increase		+36%
Nitrate		Decrease		Decrease	-84%
Orthophosphate			Increase		+179%
pH	Decrease	Decrease	Decrease	Decrease	-2.5%
Secchi	Increase		Increase		+22%
TKN			Decrease	Decrease	-82%
Turbidity	Decrease	Decrease	Decrease	Decrease	-46%

Overall, the strongest trends were the increases in chloride and orthophosphate and the decreases in pH, nitrate and TKN. Increasing visual trends were seen in Secchi depth, chloride, and fluoride, while decreasing trends were seen in pH, turbidity, alkalinity, nitrate and TKN.

An increasing Secchi depth is a key parameter in water quality conditions; an increased trend indicates potentially improving water quality. Although dissolved oxygen and temperature did not have statistically significant trends, there did appear to be a decrease in temperature and an increase in dissolved oxygen.

2.2 Lake Health Indicators

Based on a review of the trends detected in the statistical analysis, and the current limnological state and stated use goals of Lake Merced, seven water quality parameters have been chosen to represent lake health. These seven parameters are presented in four groups:

- **Dissolved oxygen (DO):** In a eutrophic water body like Lake Merced, decreased dissolved oxygen at depth can cause internal nutrient loading that can exacerbate eutrophication and reduce fish habitat. DO should be monitored at different depths.

- **Secchi depth:** Secchi depth is a relatively simple measurement indicating lake clarity. The Secchi depth can be affected by algae production or unrelated suspended solids.

- **Algae, Total Phosphorus, and Nitrogen to Phosphorus ratio (N:P):** The importance of the algae concentrations and the N:P ratio is these parameters indicate algal production and the limiting macro-nutrient. Algae production and nutrient load and interrelationship are driving factors affecting lake eutrophication.

- **E. coli and total Coliform:** E. coli and Total Coliform should be monitored since the Lake is considered an emergency water source and a recreational source and coliforms are an indicator of pathogenic microorganisms and fecal contamination.

2.2.1 Dissolved Oxygen (DO)

Dissolved oxygen concentration in Lake Merced is affected by water temperature, algal photosynthetic activity, and diffusion from the atmosphere. Lake Merced is a weakly and intermittently stratified lake (EDAW et al., 2004) and long-term hypolimnetic anoxia has not been observed although there have been 11 episodes of DO concentrations being below 5 mg/L captured by the quarterly monitoring (Figure 2). Dissolved oxygen levels can affect nutrient transformations and concentrations, aquatic organism habitat, oxidation-reduction (redox) reactions, and lake production. An increasing trend in dissolved oxygen was found, although the trend is not statistically significant. Increasing DO is a positive trend for a lake in an urban environment, especially considering its effect on fish habitat. Prolonged periods of near bottom DO levels below 2 mg/L can cause nutrient flux from the sediments into the water column and this internal nutrient loading can further increase eutrophication.

2.2.2 Secchi Depth

Over the 13-year data collection period, there has been a statistically significant increasing trend in Secchi depth in Lake Merced. As Secchi depth is an indicator of lake clarity or lake health and quality, an improving trend in lake health has been observed (Figure 3). Additionally, the public views the clarity of a lake as a measure of quality or safety; cloudy or murky water is negatively viewed.

A decline in transparency, or decrease in Secchi depth, is usually due to increases in algae and/or mineral particles. An increase in algae usually is caused by increased nutrient inputs, while clay and silt mineral particles can be carried in from surface runoff. These particles cause light to scatter and decrease water clarity. The clarity of the near surface water can also be affected by wind-induced mixing of sediments into the water column. As Lake Merced is a shallow lake and is exposed to significant winds during most of the year, varying Secchi depth measurements may be attributed to sediment disruption prior to measurement. Distinguishing between algae and mineral particle clarity issues is important to determine if mitigation efforts are considered.

This measure has been chosen as a lake health indicator because water clarity is an important indicator for the current and future water quality of Lake Merced considering its use and trophic state. Secchi depth should continue to be monitored to visually interpret water quality conditions. If a change in the trend occurs, an assessment should be made to determine the cause of reduced clarity.

2.2.3 Algae and Nitrogen to Phosphorus Ratio

As seen in previous investigations, the Lake has historically been phosphorous (P) limited (EDAW et al., 2004). It appears to have shifted from a phosphorous-limited system to a nitrogen (N)-limited or nutrient co-limited system (RMC, 2007).

Using total nitrogen (TKN + nitrate) and total phosphorous, the N:P ratios were calculated for each year to determine the ratio and limiting factor. A ratio above 16 indicates phosphorus-limited, below 16 indicates nitrogen-limited (Redfield's ratio). Until about 2005, South Lake was phosphorus-limited, indicating that algae growth was limited by a lack of phosphorus. Since the N:P ratio was significantly greater than 16, there was an excess of nitrogen available.

Around 2005, the Lake appeared to shift to become a nitrogen-limited system with an excess of phosphorus and much less nitrogen (Figure 4). Related nutrient trends show that TKN and nitrate decreased, while orthophosphate increased. Algae bloom events, measured by Algal Biomass concentration (Figure 4), have continued to occur at similar regularity during the sampling period (2001 – 2009), and the dominant phytoplankton genus found in Lake Merced samples is Oscillatoria.

2.2.4 Total Coliform & *Escherichia coli* (E. coli)

There is no discernable, consistent pattern at the South Lake Merced locations for either E. Coli or Total Coliform. California Department of Public Health provides the following threshold guidelines for recreational waters: 10,000 per 100 mL total coliform and 235 per 100 mL for E. coli. As shown in Figure 5, the coliform levels in Lake Merced have been usually well below the thresholds.

2.3 Other Water Quality Parameters

In addition to the lake health indicators, several other water quality factors can be useful in determining overall water quality trends and are discussed in the following sections.

2.3.1 Trophic Status Index (TSI)

Trophic Status Index (TSI), also known as Carlson's TSI, is measurement that uses Secchi depths and chlorophyll-a concentrations to calculate a numeric value of a water body's trophic status, or productivity level. The concept of trophic status is based on the fact that changes in nutrient levels can cause changes in algal biomass, which in turn causes changes in lake clarity measured by Secchi depth. The index ranges from 0-110, where <40 is an unproductive lake, 40-50 is moderately productive, and > 50 is highly productive. Over the past 13 years, South Lake Merced has had a TSI between 50 and 75 without a significant decreasing or increasing trend (Figure 6). Since Lake Merced historically has been considered eutrophic (EDAW et al., 2004), these values are not a surprise.

2.3.2 Measure of Hydrogen Ions (pH)

The statistically-significant decreasing trend in pH in Lake Merced south is overall a good indication. The average pH over the past 13 years is 8.1, which is somewhat high on the scale of fresh water criteria that requires pH to be between 6.5 and 8.5 yet near the level of 8.3 which would result from equilibrium with carbon dioxide in the atmosphere (Figure 7). The high pH appears to be the result of photosynthesis from algal activity.

2.3.3 Cyanobacteria

Oscillatoria is the dominant phytoplankton genus that occurs in Lake Merced. The average count at the South Lake Pump Station sampling point is 813 NU/mL, and the maximum count of 4,800 NU/mL occurred in North East Lake. The two other most dominant phytoplankton are

Anabaena, another potentially toxic cyanobacteria, and Melosira, a plankton diatom, but compared to Oscillatoria they are present in negligible amounts.

2.4 Effects of Lake Inputs on Water Quality

Of the eight measured water inputs to Lake Merced over the past 10 years, two additions in 2002 and late 2003 were volumetrically significant. Table 3 details the information on the Lake's physical properties as a result of all the additions.

It should be noted that the quarterly monitoring of constituent measurements was not made in accordance with these inputs but instead on their regular schedule. Therefore, it is difficult to quantify any changes as a true result of these water inputs. Results discussed here are estimated from the nearest quarterly measurements made before and after Lake additions.

Despite the large volumetric additions and the noticeable change in water surface elevation of those two events (Figure 8), there was not a visible increase in Secchi depth. From these results, it appears that the only additions that yielded an increase in Secchi depth were in early 2003 and in 2005, in which about half a foot in surface water elevation was added. The larger additions of water did not appear to cause an increase in Secchi depth. There is no consistent trend with respect to these variables. The effects of water inputs on other water quality variables is outlined in Table 4, which shows whether there was an increase (+) or decrease (-) in the parameter value from before to after the water input. In general, turbidity, algae, TKN and DO decreased, while orthophosphate increased. While none are significant, the consistent decrease in turbidity is positive.

Table 3: Lake Merced South physical properties as a result of lake water inputs

Date	Volume added (AF)	Initial WSE[1] (SF Datum)	Initial Volume[2]	Subsequent Volume[2]	% Volume Increase	Initial Secchi Depth	Final WSE[2] (SF Datum)	Change in WSE	Visual Change in Secchi Depth	Initial Lake Depth	Final Lake Depth
1997	128	2.0	3200	3328	4.00%	NR[3]	2.5	0.5		19.5	20.0
2000	71	3.2	3750	3821	1.89%	1.8	3.6	0.3	n	20.7	21.1
2002	**343**	**0.2**	**2950**	**3293**	**11.63%**	**1.5**	**1.3**	**1.1**	**n**	**17.7**	**18.8**
2003	111	2.5	3436	3547	3.23%	1.5	3	0.5	y	20	20.5
2003	**705**	**2.7**	**3500**	**4205**	**20.14%**	**1.5**	**4**	**1.3**	**n**	**20.2**	**21.5**
2004	1.2	3.2	3750	3751.2	0.03%	2.5	3.2	0	n	20.7	20.7
2004	0.5	3.1	3650	3650.5	0.01%	2.5	3.1	0	n	20.6	20.6
2005	96	4.7	4200	4296	2.29%	2	5.2	0.5	y	22.2	22.7

[1] WSE = water surface elevation
[2] Approximated
[3] NR = no reading

Table 4: Effect on next water quality reading (+ for increase, - for decrease)

Date	Volume Added (AF)	DO	Temp.	Turbidity	Total P	Ortho P	TKN	Nitrate	Ammonia	pH	Algae	TDS	Conductivity	Hardness	Alkalinity
1997	128	NR[1]													
2000	71	+	+	-	-	NC	NR	NC	-	+	+	NC	NC	NC	NC
2002	**343**	**-, +**	**-**	**-**	**+**	**+**	**-,+**	**-,+**	**+**	**-**	**-**	**-**	**-**	**-**	**NC**
2003	111	NC[2]	+	-	-	+	-	-	+	+	-	NC	-	-	NC
2003	**705**	**-**	**-**	**-**	**-**	**+**	**-**	**NR**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
2004	1.7[3]	-	-	-	-	+	-	NC	NC	-	-	NC	+	NC	NC
2005	96	-	+	+	+	+	-	NC	+	+	NR	NC	NC	NC	NC

[1] NR = no reading
[2] NC = no change
[3] 2004 events are combined because of small volume

Section 3: Monitoring Plan Data Set Characteristics

The current Lake Merced Monitoring Plan was evaluated to determine if the Plan is sufficient to capture the key water quality parameter data points that determine the health of Lake Merced. Review of the current water quality data determined that the Monitoring Plan could be altered. Some parameters have little variation over time and/or depth, and may not need to be monitored as frequently. Other parameters may need to be monitored more frequently to capture changes that may occur between current sampling events.

3.1 Parameters with Little Variation over Time

For each water quality parameter, the average, standard deviation and CV were calculated for all sampling points over time and depth. The parameters listed in Table 5 have the smallest CVs, indicating that they have remained constant over time and may not need to be monitored as frequently, if at all.

Table 5: Parameters relatively constant over time

Parameter	CV Value of Complete Data Set at South Lake Pump Station
Alkalinity	0.11
Chloride	0.12
Conductivity	0.11
Fluoride	0.23
Hardness	0.10
MTBE	0.00[1]
TDS	0.11

[1]MTBE varied between 1997 and 2003 but has not been detected since February 2003

Bromide and sulfate were not monitored after 1998.

3.2 Parameters with Little Variation over Depth

For each water quality parameter, the average, standard deviation and CV were calculated for all depths on each sampling date to determine if the parameter values changed with depth. The parameters listed in Table 6 have the smallest average CVs over depth, which suggests that they may not need to be monitored at various depths.

Table 6: Parameters relatively constant over depth

Parameter	CV Value over Depth at South Lake Pump Station
Chlorophyll-a	0.09
MTBE	0.003
Nitrate	0.07
ORP	0.08
TOC	0.09
Turbidity	0.08

Plankton, Secchi depth and Total coliform/E. coli were only monitored at one depth or through the complete water column.

As discussed in previous reports, Lake Merced is a shallow lake influenced by the temperate environment and consistent winds of its location. This characteristic and the atmospheric conditions typically result in weak and intermittent stratification. This has been confirmed by water quality sampling data as near bottom temperature, DO, and ORP infrequently deviate from the near surface conditions. There have been several near-bottom low DO episodes (Figure 2) but typically, near-bottom DO levels rise by the following sampling event. Quarterly sampling makes the determination of the duration of stratification difficult. In addition, the resulting decline in DO and duration of low DO in the hypolimnion during these events is difficult to quantify. Longer periods of low near-bottom DO levels are significant as sediment metal oxides may become reduced over time allowing a release of nutrients from the sediments (i.e., internal nutrient loading). A study including intensive sampling of DO depth profiles could help quantify the stratification and low DO episodes.

Section 4: Conclusions and Recommendations

After review and analysis of water quality data from 1997 to 2008, seven water quality parameters were chosen to indicate lake health. These seven parameters can be monitored by SFPUC Water Resources staff by the following graphs:

Dissolved Oxygen by depth (Figure 2) – Tracking DO allows staff to observe a key constituent for fish health, observe periods of stratification and production resulting in low near-bottom DO levels, and observe near-surface algae proliferation resulting in DO levels greater than saturation. Ideal DO levels are greater than 5 and less than 10 mg/L.

Secchi depth (Figure 3) – Tracking the clarity as an overall indicator of lake health allows staff to determine the aesthetic quality of the Lake and identify episodes of loss of clarity due to either algal blooms, high turbidity inflows, or sediment suspension due to lake mixing. Ideally, Secchi depths should remain trending at 1.5 feet or greater.

Algae concentration and nutrient information (Figure 4) – Tracking algae concentration is a good indicator of eutrophication and allows the observation of how current levels compare to historical levels. Tracking total phosphorus and N:P allows an indication of future algae production.

Coliform levels (Figure 5) – E. Coli and total coliform levels have historically been well under CDPH thresholds for recreational waters and this graph will allow staff to observe if there is a deviation from typical levels. Ideal levels are well below CDHP recreational threshold levels.

From the water quality data analysis and graphical representation of the chosen lake health indicators, the health of Lake Merced appears to have remained relatively constant from 1997 to 2008. Lake water quality has been slightly affected by large lake additions but these events have not changed observed trends.

Dissolved oxygen levels have been affected by periods of weak stratification and production in the lower reaches of the Lake and algae production in the near-surface reaches. Historical DO levels typically remain above the warm water habitat threshold. There has been a statistically significant increase in Secchi depth over the studied time period indicating increased clarity over time. This is a positive indication of increasing lake health but due to the frequency of sampling and the potential for wind mixing and algal blooms to affect this measurement, Kennedy/Jenks Consultants recommends monitoring this trend to see if it continues.

There has been a shift in nutrient limitation during the 12 year monitoring period. An apparent phosphorus limited system changed to being more nitrogen or co-limited. As Lake Merced is a eutrophic system (Figure 6), large nutrient additions should be avoided to minimize the proliferation of algae. Coliform levels are well below CDHP recreation threshold levels and this trend should continue unless there is a significant change in lake management.

Table 7 below presents the recommendations for possible changes to the Lake Merced water quality monitoring program. The data were analyzed to determine which parameters change least frequently over time and depth. The repeated analysis of samples for parameters that historically do not significantly change can be waste of field and laboratory effort.

As the use of Lake Merced is different than drinking source reservoirs similarly monitored by SFPUC Natural Resources department, a simplified monitoring program for Lake Merced could be established that meets the goals of monitoring the condition of Lake Merced. The recommendations below include parameters to monitor, the frequency of sampling events, and the depth at which samples could be measured. In addition, it is not recommended to discontinue analyses that indicate limnological and use-based conditions that are applicable to Lake Merced.

Table 7: Lake Merced Monitoring Recommendations

Constituent	Current Sampling Location	Current Sampling Frequency	Current Sampling Depth	Recommended Sampling Location	Recommended Sampling Frequency	Recommended Sampling Depth
Algal Biomass	4	Q	2	4	Q	2
Alkalinity	4	Q	M	4	A	M
Ammonium (NH_4^+)	4	Q	M	4	Q	M
Bromide (Br^-)	4	Q	M		None	
Chloride (Cl^-)	4	Q	M	4	A	S
Chlorophyll	4	Q	2	4	Q	2
Conductivity	4	Q	M	4	Q	M
Dissolved oxygen (DO)	4	Q	M	4	Q	M[1]
E.coli	4	Q	1	4	Q	1
Fluoride (Fl^-)	4	Q	M	4	A	S
Hardness	4	Q	M	4	A	S
Iron (Fe)	4	Q	M	4	Q	S-B
Lead (Pb)	4	Q	2	4	Q	2
Manganese (Mn)	4	Q	M	4	Q	S-B
MTBE	4	Q	M	4	A	S
Nitrate (NO_3^-)	4	Q	M	4	Q	M
Orthophosphate	4	Q	M	4	Q	M
Oxidation-reduction potential (ORP)	4	Q	M	4	Q	M[1]
pH	4	Q	M	4	Q	M[1]
Plankton	4	Q	1	4	Q	1
Secchi depth	4	Q	N/A	4	Q	N/A
Sulfate (SO_4^{2-})	4	Q	M		None	
Temperature	4	Q	M	4	Q	M
Total Coliform	4	Q	1	4	Q	1
Total dissolved solids (TDS)	4	Q	M	4	A	M
Total Kjeldahl nitrogen (TKN)	4	Q	M	4	Q	M
Total organic carbon (TOC)	4	Q	M	4	Q	S
Total phosphorus	4	Q	M	4	Q	M
Turbidity	4	Q	M	4	Q	M

4 – current four locations: Lake Merced North, Lake Merced North East, Lake Merced South- Pistol Range, Lake Merced South-Pump Station
Q – quarterly
2 – currently sampled at two depths
M – multiple depths
A – annual
None – discontinue sampling
S – surface only
1 – currently sampled at one depth or through the water column
S-B – surface and near bottom
[1] – note time of day

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Lake Merced Water Quality Data Organization and Review

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January 2010

Figure 1 – Lake Merced Sampling Points

2-23-0862

Exhibit 6

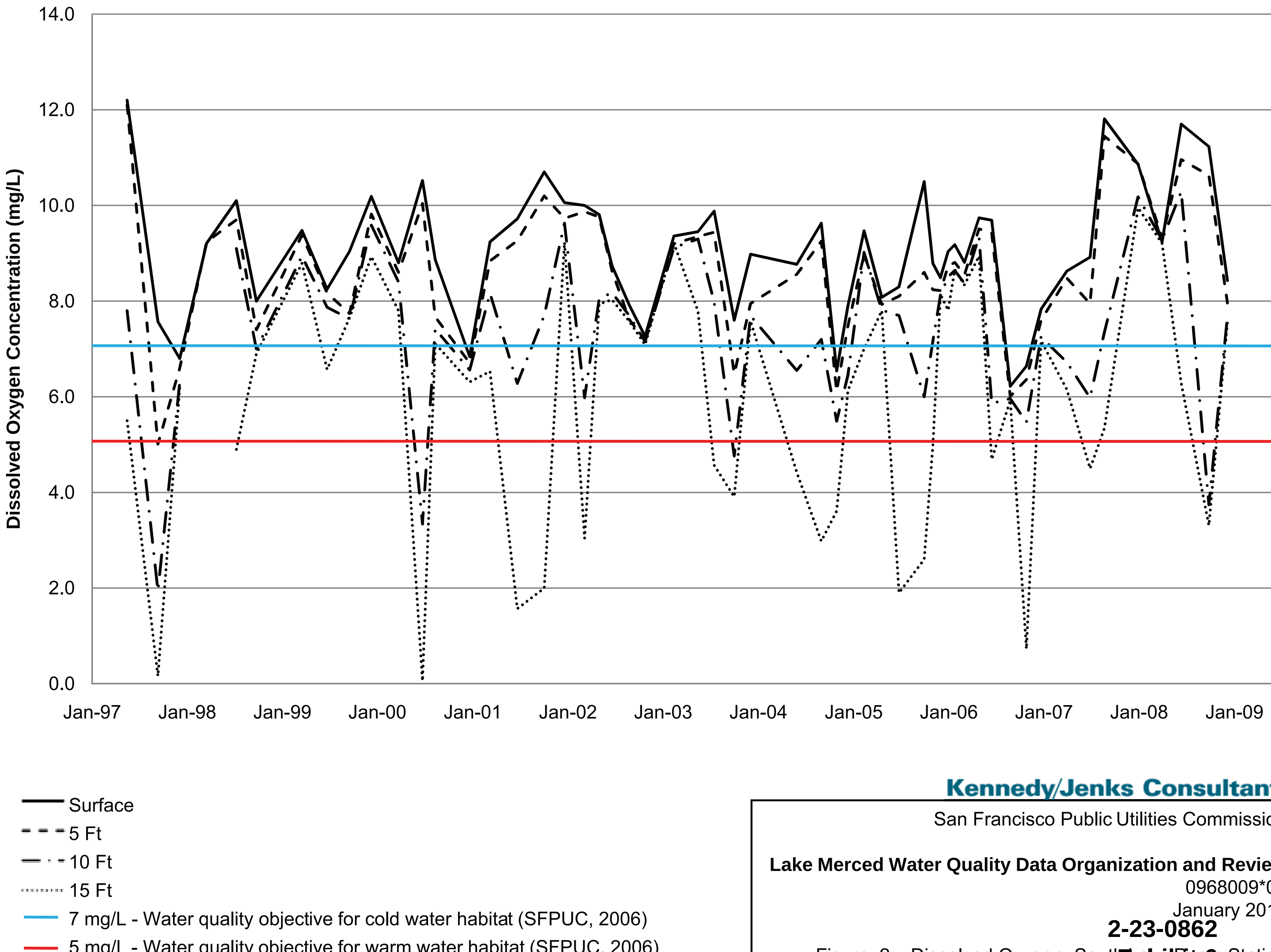

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Figure 2 – Dissolved Oxygen, South Lake Pump Station

2-23-0862

Exhibit 6

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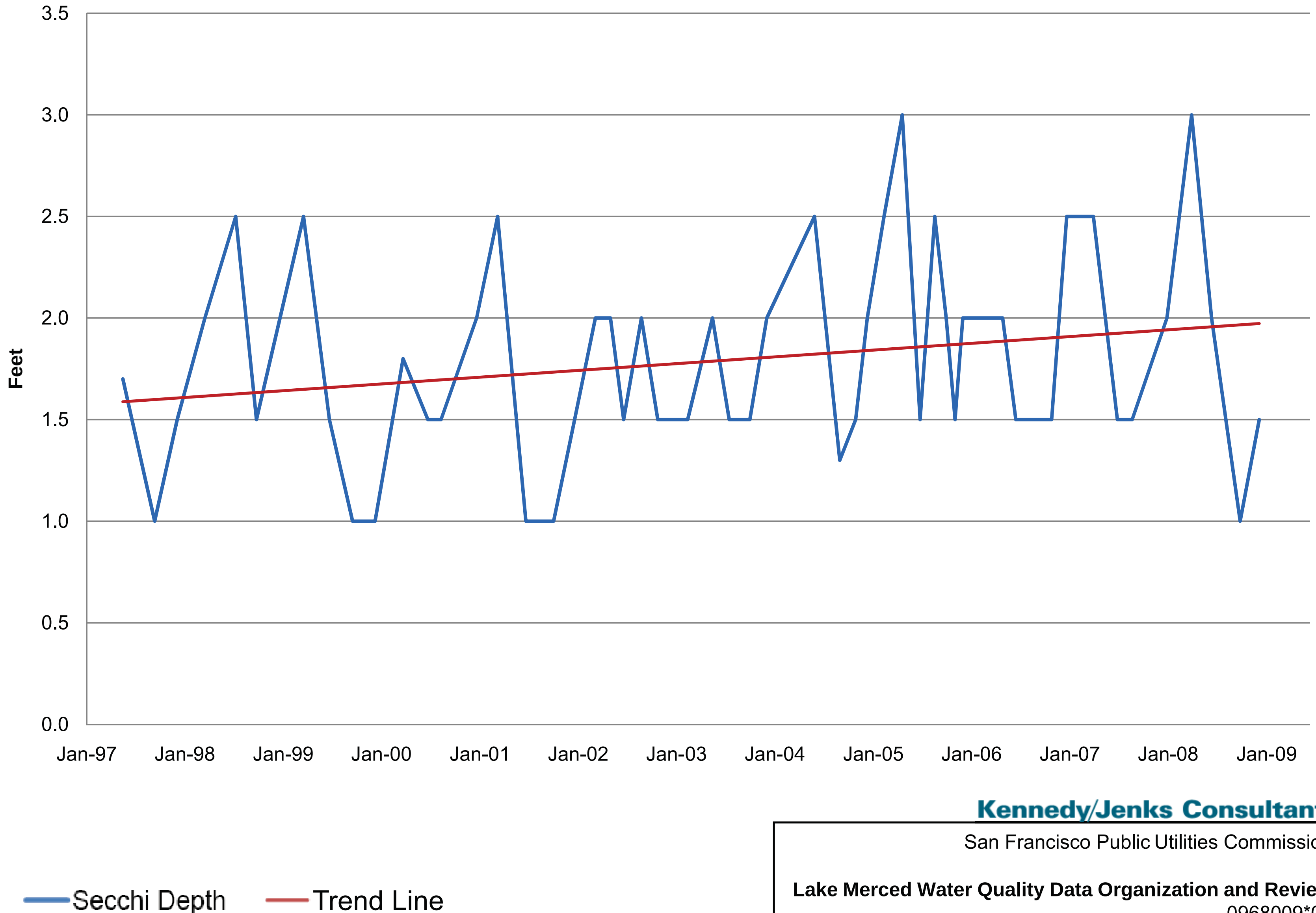

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Figure 3 – Secchi Depth, South Lake Pump Station

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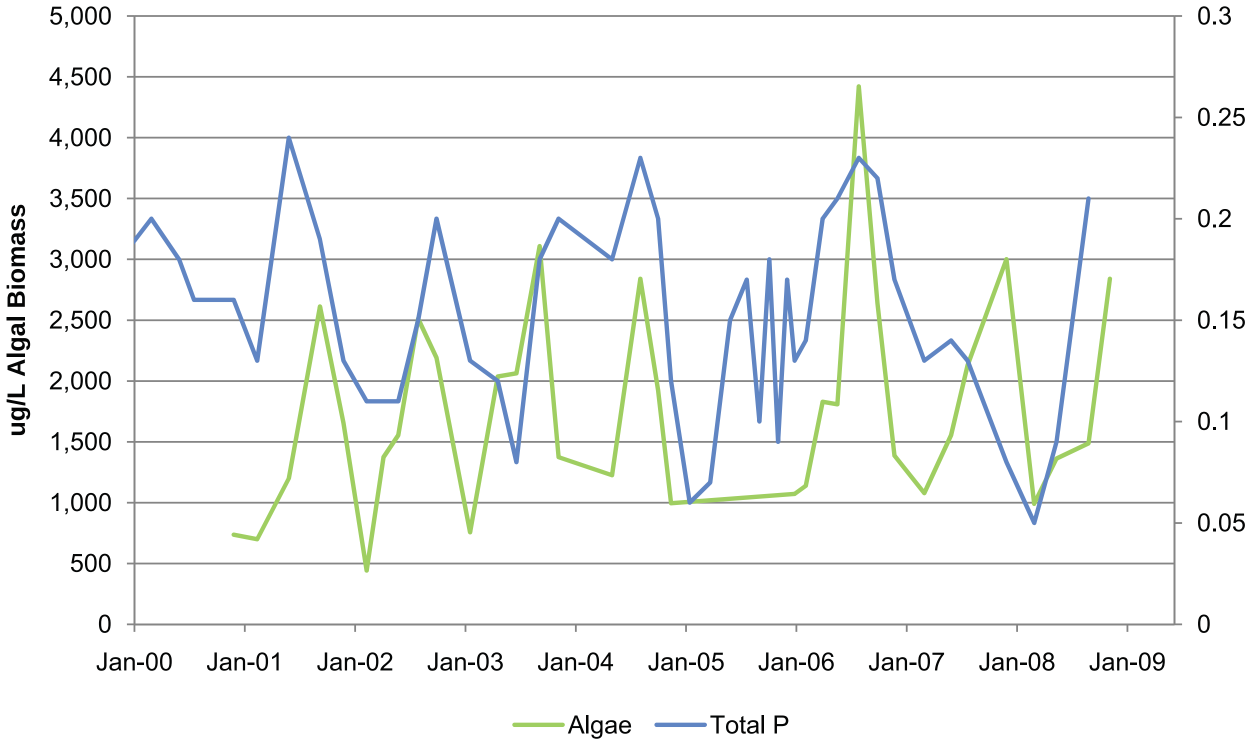

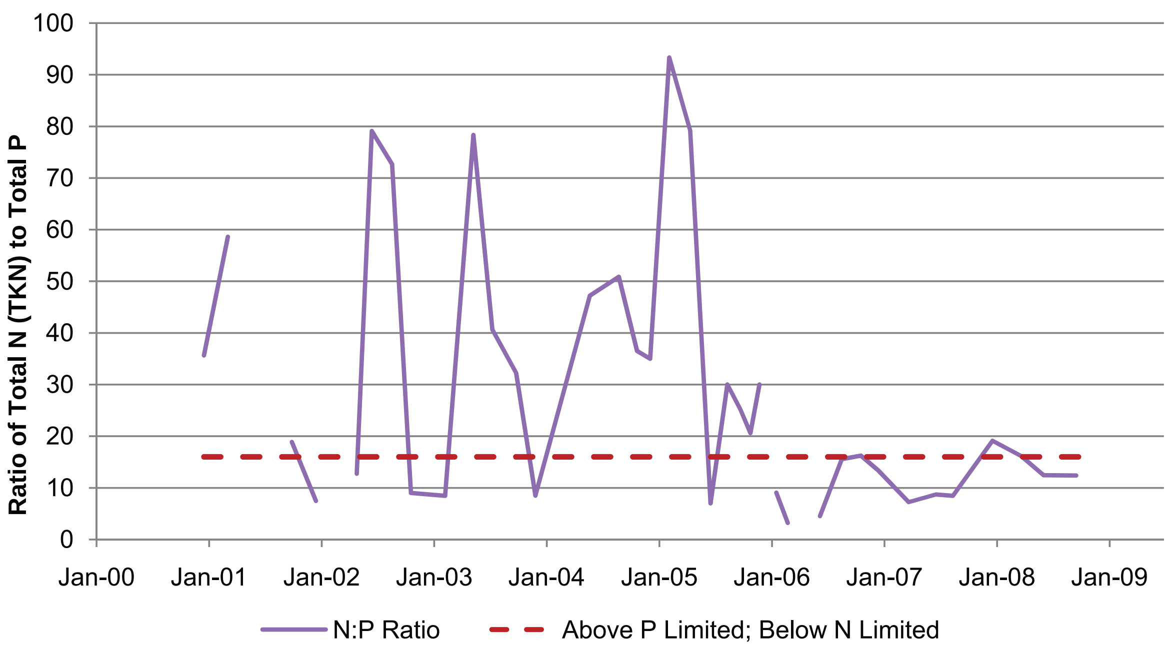

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Figure 4 – Algae Concentration and Nutrient Information, South Lake Pump Station

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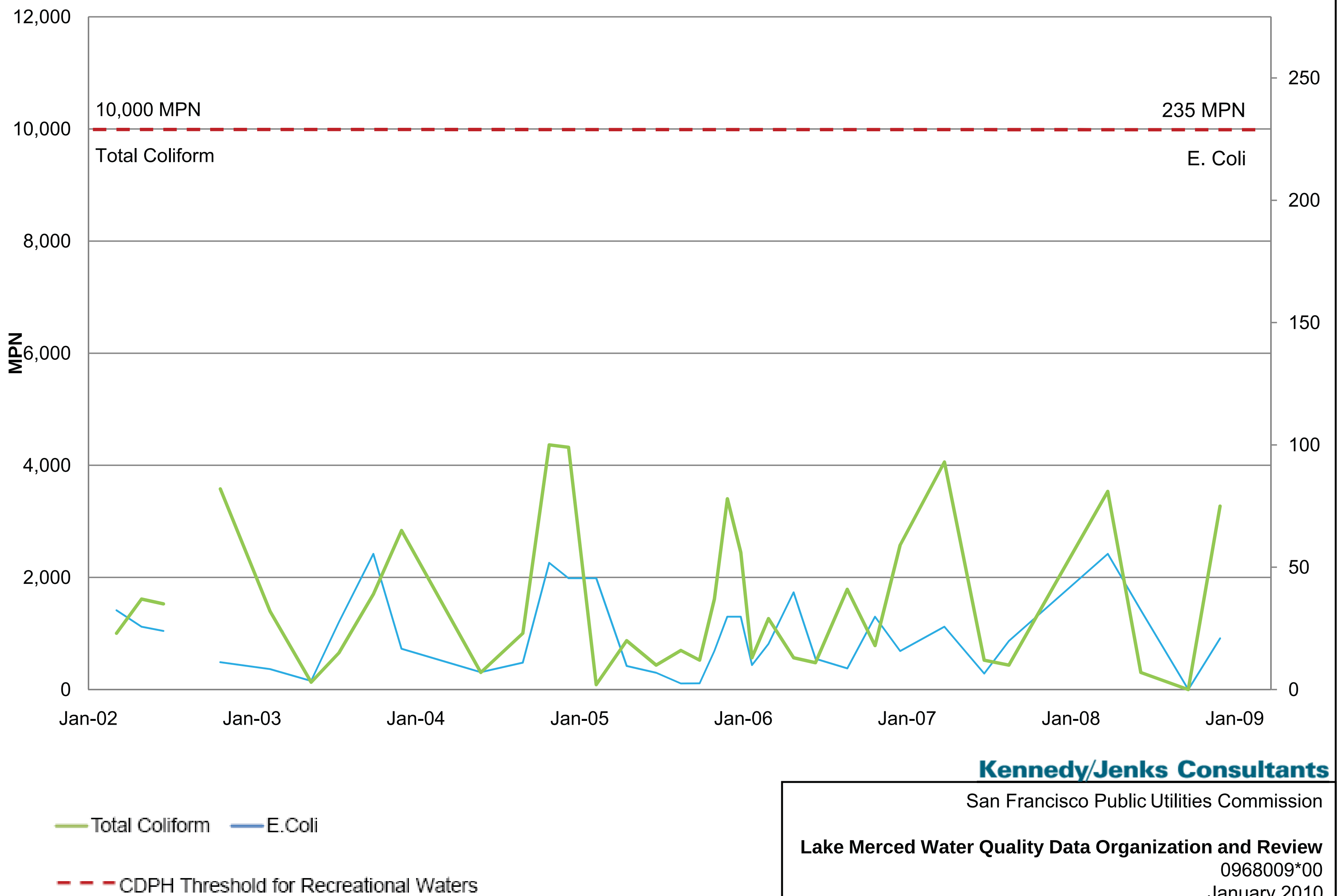

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Figure 5 – Coliform, South Lake Pump Station

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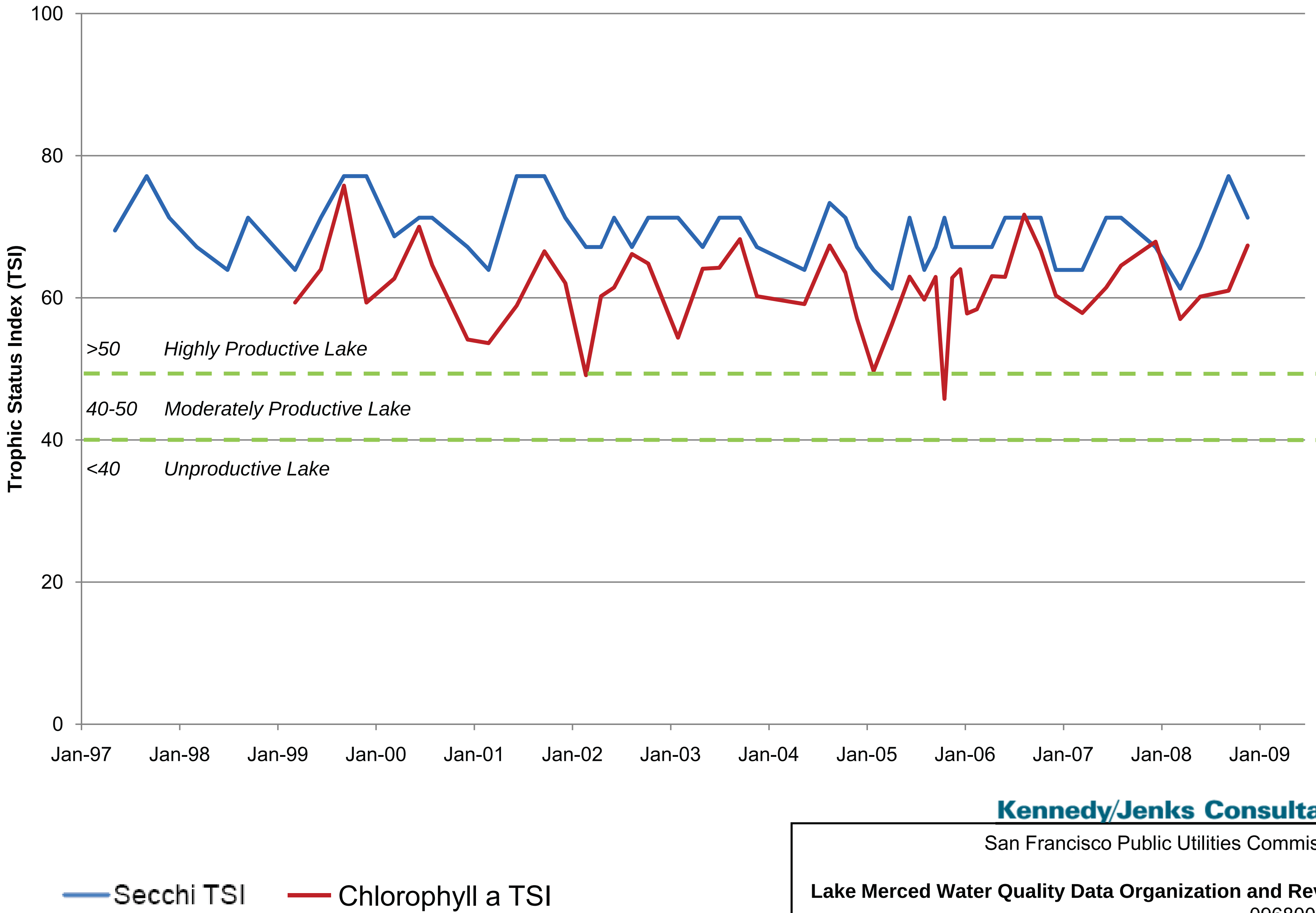

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Figure 6 – Trophic Status Index, South Lake Pump Station

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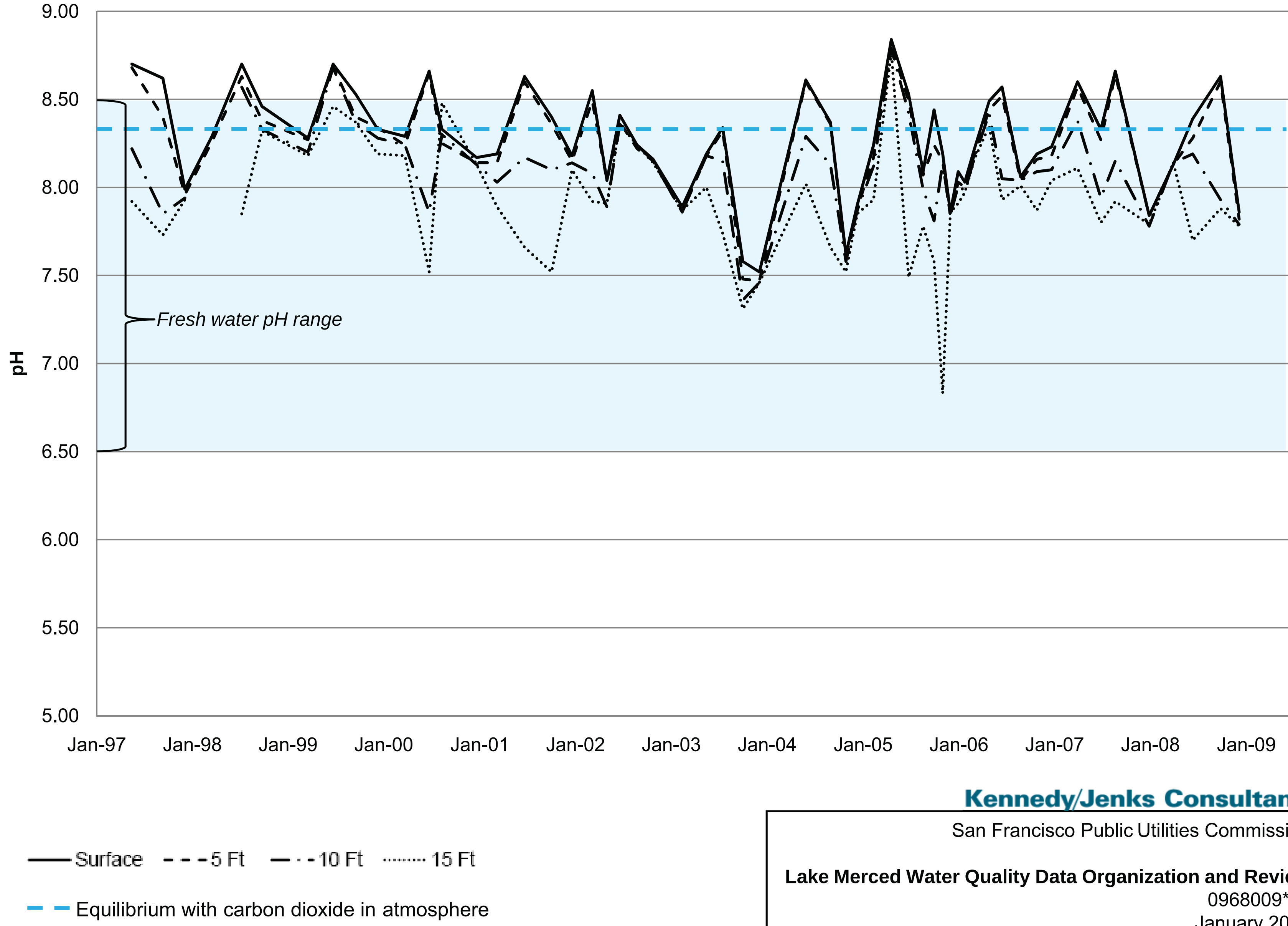

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Figure 7 – pH, South Lake Pump Station

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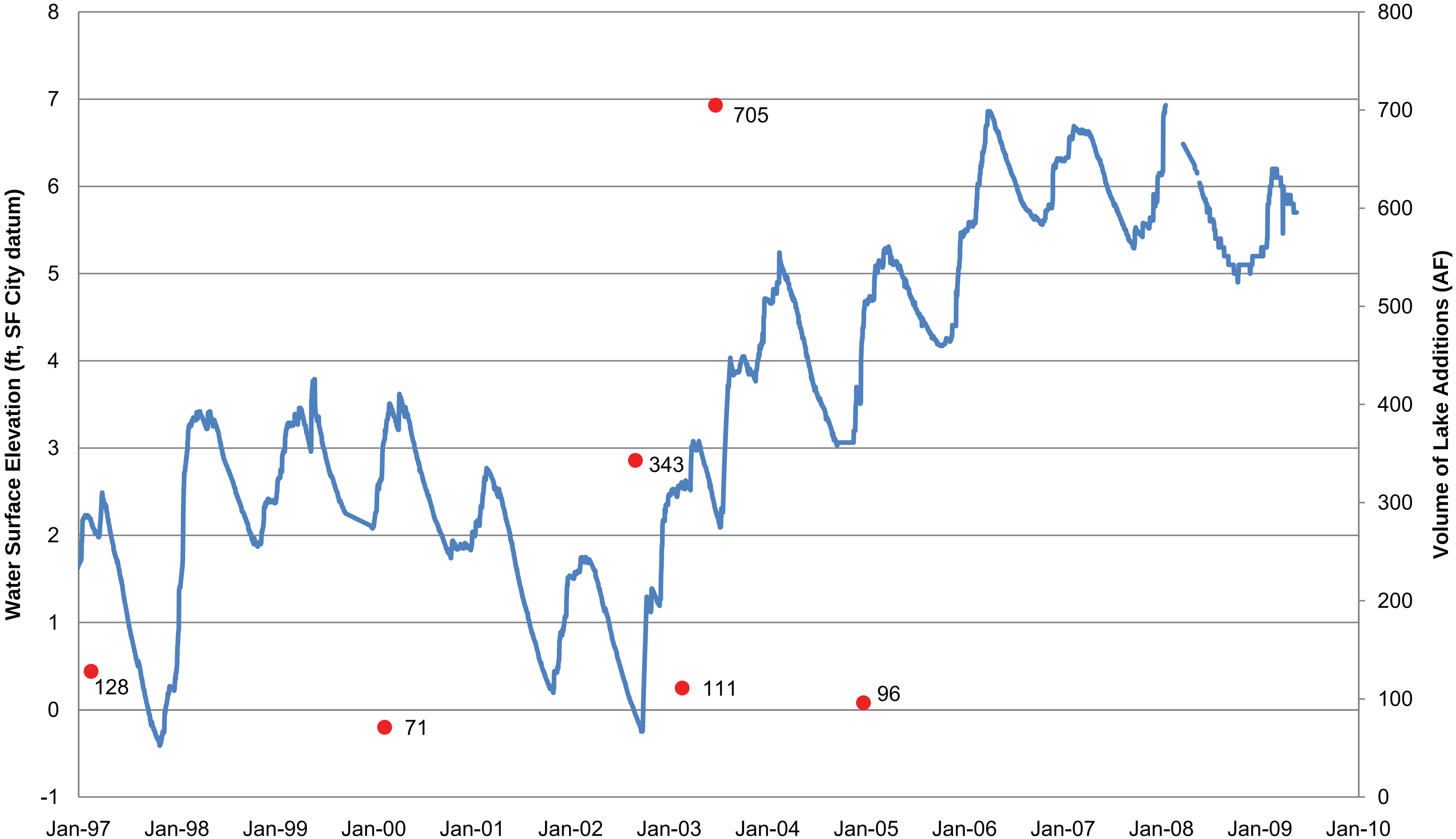

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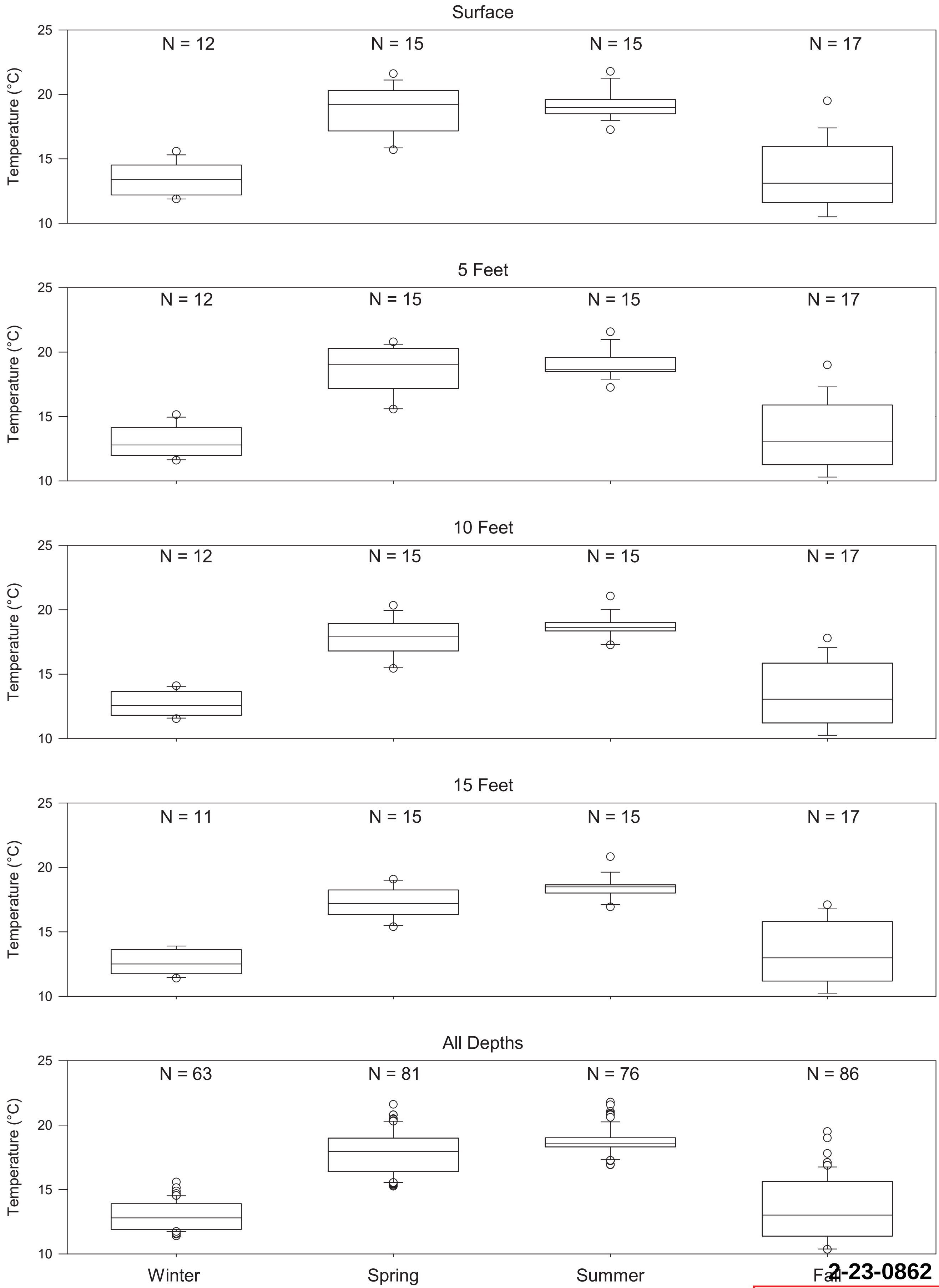
Figure 8 – Water Surface Elevations:1997-2009: South Lake

Lake Merced South - Pump Station: Temperature



SOURCE: Kennedy/Jenks Consultants, 2010; ESA, 2013

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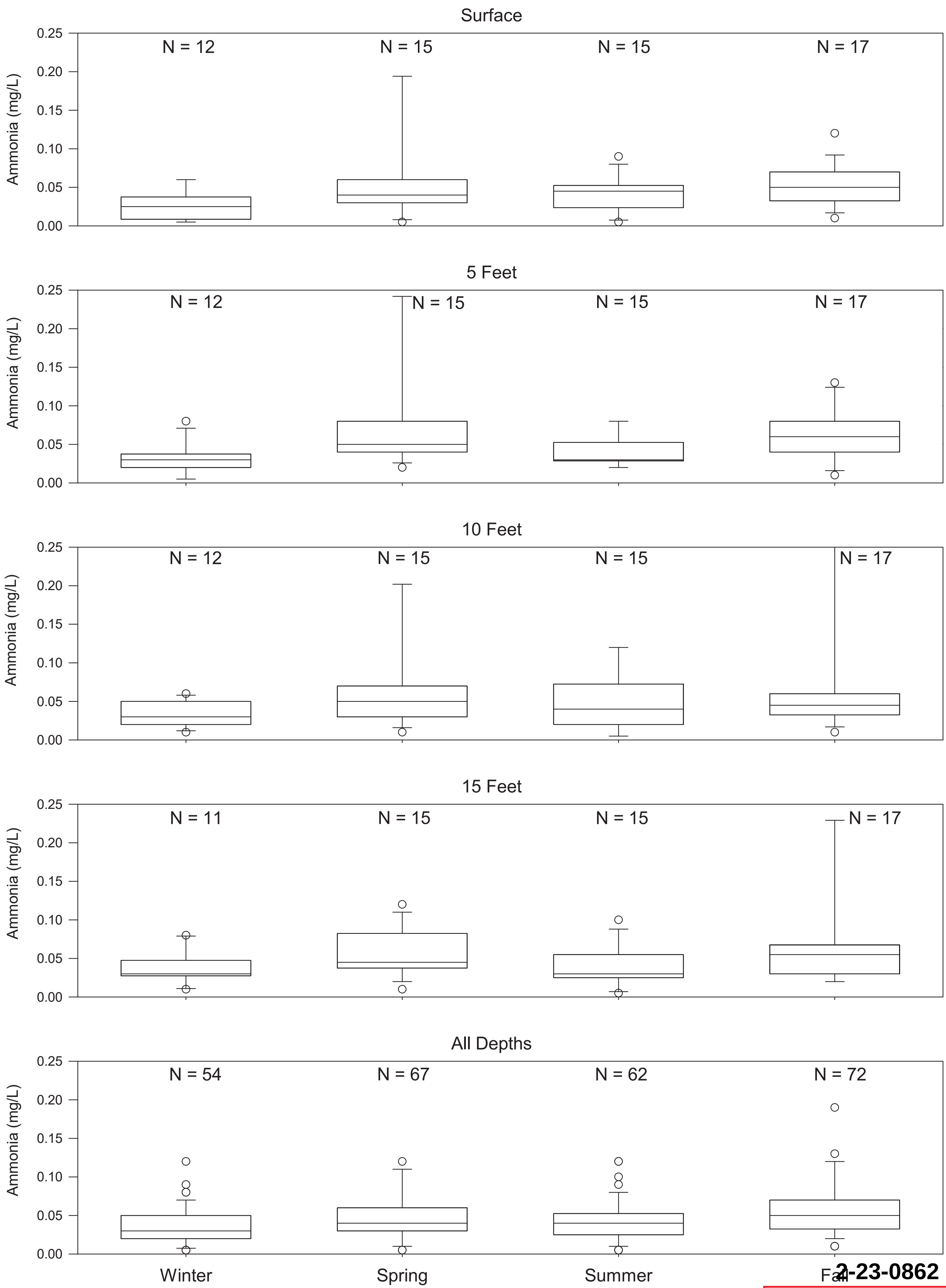
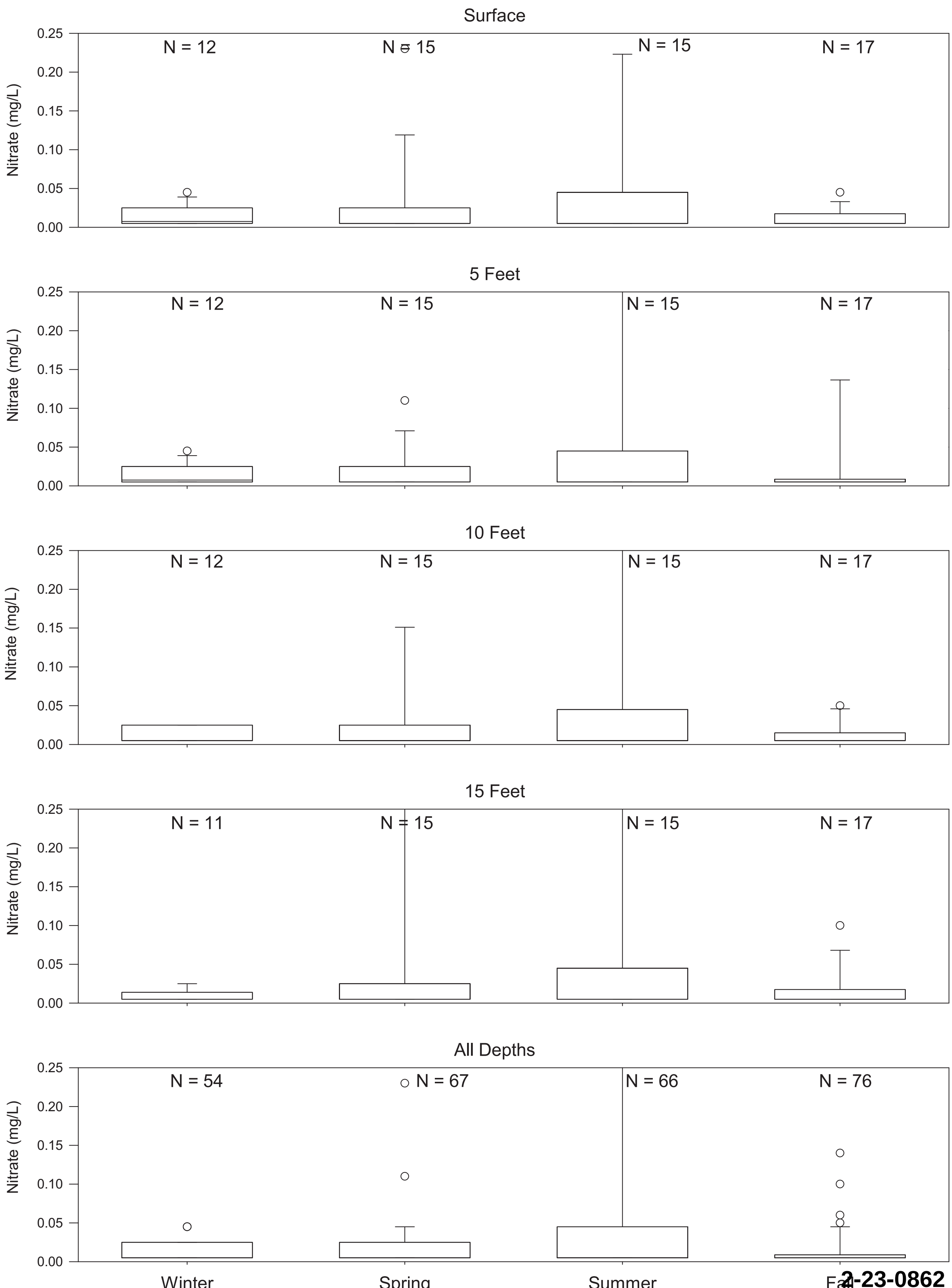
Lake Merced South - Pump Station: NH_3-N



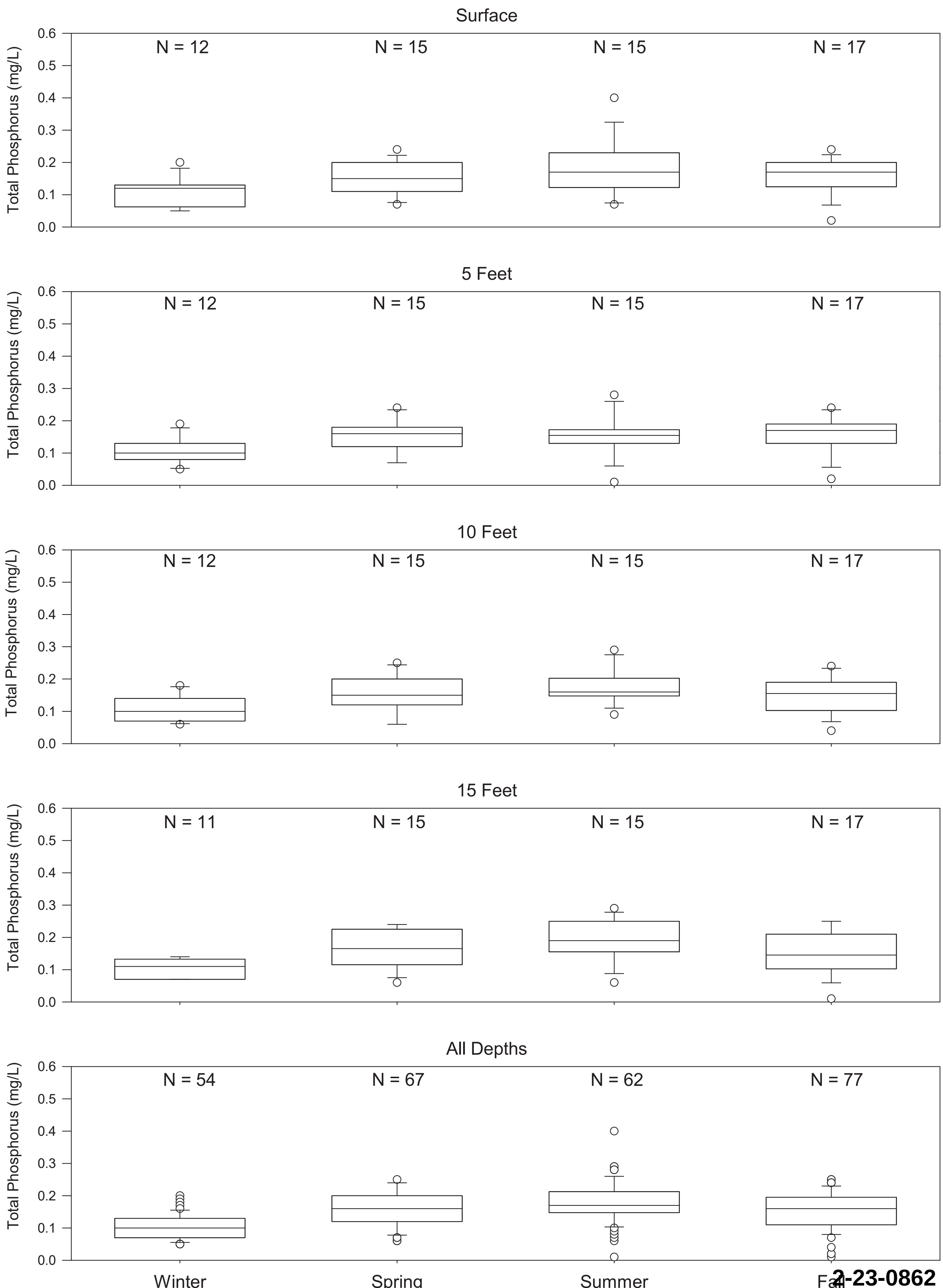
SOURCE: Kennedy/Jenks Consultants, 2010; ESA, 2013

Lake Merced South - Pump Station: NO_3-N



SOURCE: Kennedy/Jenks Consultants, 2010; ESA, 2013

Lake Merced South - Pump Station: Total Phosphorus



SOURCE: Kennedy/Jenks Consultants, 2010; ESA, 2013

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APPENDIX E

Preliminary Assessments of Water Quality Monitoring Data and Project Effects

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WATER QUALITY EFFECTS OF INCREASING WATER DEPTH IN THE SOUTH BASIN OF LAKE MERCED, SAN FRANCISCO: DISSOLVED OXYGEN, EUTROPHICATION & pH

By: Alex Horne, Ph. D.

For: ESA

12 July 2012

Revised 31 July 2012

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SUMMARY

Increases in water depth of 0.5 to 3.5 feet in Lake Merced by adding storm water would restore some of its historical inflow, reduce flooding in Daly City, and moderate the costs of increasing the size of a tunnel to carry away excess storm water to the sea. Deeper water will reduce the frequency of mixing in summer and, by reducing the amount of nutrients stirred up, could eventually improve water quality. On the contrary, adverse changes in water quality are possible due to nutrients added in the winter storm water supply. The balance between increased depth and added nutrients will determine the net effect on eutrophication in the lake.

Due to algal growth, the South Basin of Lake Merced is listed as impaired for high alkalinity (pH) in surface water and low dissolved oxygen (DO) in deep water. During photosynthesis, algae use up acidic carbon dioxide and increase the pH near the surface. When algae sink, their decay depletes dissolved oxygen producing anoxia on the lake bed. Prolonged anoxia increases the flux of nutrients from the sediments. If these nutrients are mixed up to the surface, more algae can grow and a cycle of eutrophication results, increasing the oxygen and pH concerns. On the other hand, if the lake is well-mixed, oxygen is continually supplied to the deep water and nutrients and pH are reduced. The more eutrophic the lake, the more frequently mixing is needed to supply DO. Lake Merced's cool, foggy; ocean-side location enhances wind mixing and, until recently, was thought to mix sufficiently to keep DO in bottom waters above 5 mg/L for most of the summer and autumn with only occasional depletions.

Data from Lake Merced collected over the last 13 years has been summarized and interpreted recently in two reports (EDAW, 2004, Kennedy-Jenks, 2010). Additional measurements were made from 2011-12 when continuous recording probes for DO, temperature and pH were used for the first time. The new data showed that though substantial mixing occurred on average every 9 to 11 days the rate of mixing was insufficient to carry enough oxygen down to offset the biological oxygen demand in the sediments. Complete mixing between mid August and October 2011 probably occurred only once on September 17th and 18th. In 2011, near bottom water DO recorded at LM-3____ was greater than 5 mg/L for only 5 percent of the period from mid-August to mid-October. However, functional anoxia (< 2 mg/L DO) for several weeks is required in the bottom waters before the sediments release substantial amounts of ammonia and phosphate. In Lake Merced functional anoxia occurred in 2011 at station LM3 for 34% (19 non-continuous days) of the time in summer and fall. Based on the small changes in ammonia and total-P in the same seasons, the period of functional anoxia does not appear long enough to increase sediment nutrient flux substantially. Nonetheless, some nutrients in deep water were elevated in summer and occasional mixing will transport them to the surface.

Effect of increased depth in decreasing mixing, lowering nutrients and decreasing algae. A mixing model was used to predict the effects on Lake Merced of increased depth. Increases of 0.5 to 3 feet will reduce the frequency of holomixis from 11 days to 20 days (at + 2.5 feet water surface elevation [WSE]) and 26 days (at + 3.5 feet). The changes were not linear since wave energy propagation down the water column is almost logarithmic. The decrease in wave-driven swirling on the bottom mud will approximately halve from 0.1 cm to 0.04 cm. Assuming a linear relationship between mixing and nutrients stirred from the sediments and that only a part of the nutrients will result in net algal growth, a small, progressive reduction in algae (max. 7.0 µg/L chlorophyll *a* or 23%) with increases in depth is predicted. Due to the curvilinear relationship of

chlorophyll and water clarity (Figure 1), the small algal reduction would not show any effect on water clarity up to +2.5 feet but a small improvement in water clarity (~ 23%) may occur at + 3.5 feet. In terms of public perception, at these relatively high concentrations of algae, the human observer on the shore would probably not notice a 23% increase in water clarity.

Less mixing may increase the periods of low DO in deep water. Although only a few measurements are available, comparing incidents of low DO from 1997-2003 (water elevation 0-3.8 ft) with those from 2004-2010 (water elevation 4-7 ft), increased depth did reduce DO in deep water. The effect was most pronounced in autumn. The bottom DO in September-October 1997-2003 was > 5 mg/L 50 % of the time but only 20% of the time from 2004-2010. The increased low DO values are similar to those found with the 2011 more detailed measurements.

Effect of increased storm water inflows in increasing nutrients and algae. Storm water currently averages 460 µg/L of Total Inorganic Nitrogen (TIN = nitrate + ammonia) and 170 µg/L of Total Phosphorus (TP) while the lake in winter averages 90 µg/L TIN and 150 µg/L TP. The ratios of bioavailable N:P (TIN: 0.8 TP) are 0.75 (lake) and 3.4 (storm water), indicating a strong N-limitation for algal growth. In addition, TIN is virtually absent in the lake in the growth season (<10-25 µg/L) while at the same time TP is abundant with a median value of 120 µg/L and a minimum of 67 µg/L (Aug-Oct, 2011). Typical water quality standards for TP are ~ 10-15 µg/L and P is obviously in excess in Lake Merced, as it is in many waters in dry regions. Because storm water TP is very similar to lake TP, there will be no effect of TP added in storm water. In contrast, the TIN added via storm water will increase lake TIN and possibly increase algae. Using a simple model, the amounts of storm water added with the targets of +0.5 to +3.5 ft increase in water depth were shown to have relatively minor effects on algae. Increases in chlorophyll of 1.9 to 10.7 µg/L over the base condition of 30 µg/L were estimated to occur with more algae as more storm water was added.

Net effect of increasing depth with storm water. There is an almost equal and opposite eutrophication effect of the two processes of decreasing mixing with greater depth and increased nutrients with more storm water added. The net modeled change in algae in the lake is a slight increase in algae 1.3-12.5% or 0.4 to 3.8 µg/L chlorophyll *a* (chl a) increase or a lake average concentration of 30.4 to 33.8 µg/L) depending on how much water is added. These results assume TIN is the growth-limiting nutrient for algae rather than light. If TP was growth-limiting, the overall effect would be a decrease in algae ranging from 0.6-5.4 µg/L (2-18%) because increased depth reduces all nutrients but increased inflow makes little difference to TP since lake and storm concentrations are similar.

Alkalinity and pH. The pH of surface water layers in Lake Merced frequently exceeds the Basin Plan maximum of pH 8.5. Based on the lake's moderately high alkalinity (mean = 172 ppm; range 136-230), the equilibrium pH of the Lake Merced water can be predicted empirically as about 8.5. The actual daily average pH in September 2011 was 8.45 with an average daily minimum of 8.2 and an average daily maximum of 8.7, thus corroborating the predictions based on alkalinity. September 2011 has the most detailed data set gathered using *in situ* probes and is a typically a month of frequent blue-green algae nuisance blooms. In addition, occasional measurements of pH over the last 40 years also average ~ 8.5. As is common in eutrophic lakes (L. Merced chlorophyll *a* mean ~ 30 µg/L), algal photosynthesis dominates the daily pH fluctuations and cause most pH values above 8.5. Due to the buffering effects of the alkalinity, pH fluctuations driven by photosynthesis in Lake Merced were small relative to other lakes. In September 2011 the average diel change in pH was only 0.5 while most eutrophic lakes show twice this value. However, because even the small increases occurred on a higher base pH level than many other lakes, the resultant pH often exceeded current Basin Plan standards.

The alkalinity in Lake Merced has an unusual history. The lake was mostly likely once a brackish water estuarine channel in summer (~ sea water alkalinity?), a storm-flushed channel during winter storms (low alkalinity), a dammed drinking water storage reservoir (low alkalinity) and now a terminal lake with a long water residence time (moderately high alkalinity). All terminal lakes eventually have high alkalinity and high equilibrium pH and this may explain the current moderately high baseline pH in Lake Merced. The highest pH values (9.1) in Lake Merced were not balanced by low values (7.0 -7.5) as would be expected for a lake with a watershed dominated by sandy lightly-buffered soils. Poorly buffered waters typically show large fluctuations in pH but with expected low values well below the neutral pH of 7. Alkaline base ions are accumulating over time although this is more evident over the last 50 years in the more isolated North and East Lake basins. Regional alkalinity variations explain differences in pH standards in various states in the US, some of which recommend the same pH range (6.5-8.5) while others use 6.0-9.0 – a standard with which Lake Merced would generally be in compliance.

Two water quality standards (DO and pH) are currently not met in Lake Merced. . Because the model predicts small increases or decreases in algae with increased depth and added storm water, no substantial difference is anticipated to occur in the already low bottom DO levels or the "background" high alkalinity and pH. The two standards may still not be reached with higher lake levels.

Suggestions for meeting the DO and pH standards. Three conventional methods (one watershed, one in-lake management and one combination of both) could be used to ensure that DO and pH were maintained at levels that would remove them from the 303 (d) listing. The model indicates that ***any watershed method(s*)** that would result a change of chlorophyll of < 1 µg/L (in no effect) would need to reduce TIN in the storm water to ~ 360 µg/L or about 78% of the current concentration. However, with no reduction in TIN in storm water the model predicts the average chlorophyll increase in the lake to only an average of 2 µg/L or 7% above present and would not make a visible difference to the water clarity. The inability of even large reductions in TIN in storm water to decrease algae in the lake is due to the internal loading of nutrients from the sediments in summer which is not influenced by winter inflow except over very long time periods. One possible solution to the current higher pH excursions and baseline alkalinity in Lake Merced is a large reduction in chlorophyll by substantially reversing eutrophication. To achieve the pH standard of 8.5 from an average base of 8.2 would require halving current chlorophyll concentration assuming that would halve the photosynthetic rate. Due to hysteresis effects, an algal decrease of that magnitude may be infeasible in a shallow lake with an urban drainage and legacy nutrient pollution in the sediments. Hysteresis is defined as the dependence of a system both its current and past environment. An example is a rubber band which, if well-stretched, will never or only slowly return to its original length. In lakes, pollution and eutrophication stresses change the ecology and food web so much that even total elimination of the stressors like an increased external nutrient load will not return the lake to its original trophic state; at least for decades and maybe centauries. The ***lake management method*** for the current or up to + 3.5 feet depth increase options require some form of aeration-mixing. This would guarantee DO > 5 mg/L for most all the time and probably equilibrate pH close to the limit of 8.5.

The combination method is flushing the lake with lower alkalinity storm water when appropriate to dilute and flush out higher alkalinity water lying near the lake bed. This solution is ecologically attractive since it restores some of the natural original hydrology. Some evidence that this method would work is the much lower pH (~7.0) achieved briefly in 2006 following heavy rains.

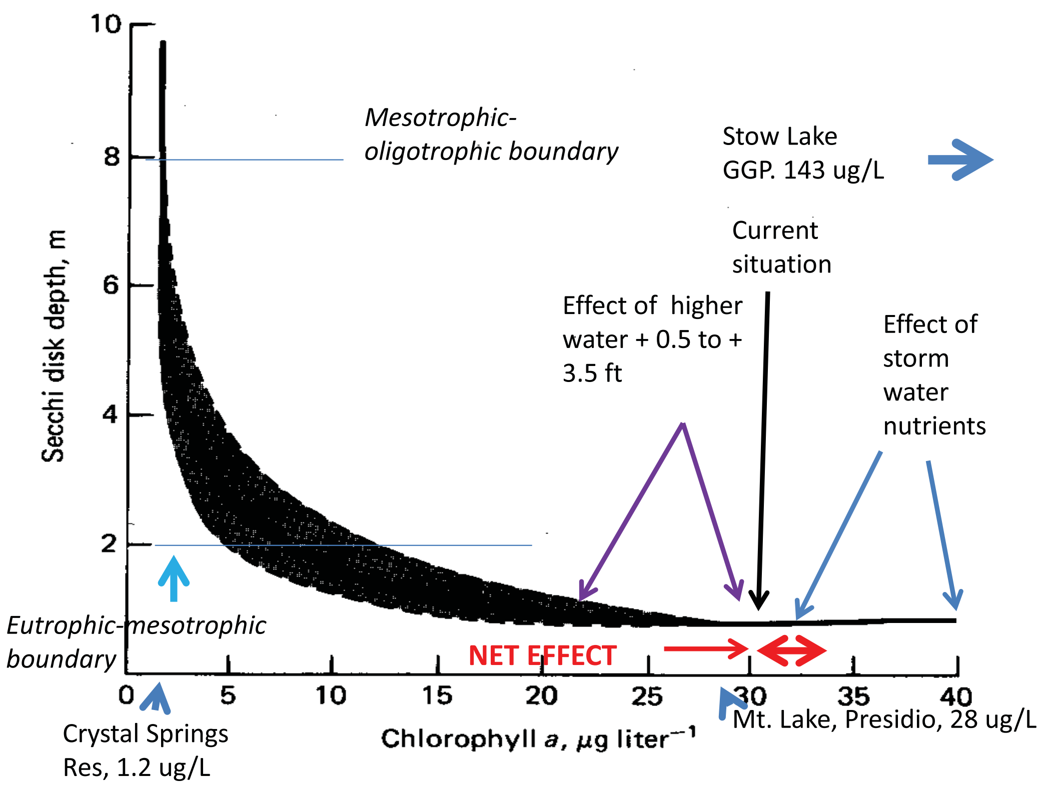

Figure 1. Relationship between chlorophyll *a* and water clarity for the range of proposed depth increased as measured by Secchi disk depth.

INTRODUCTION

Definitions & Technical Explanations

- Thermal stratification – The lake water becomes divided into two layers on the basis of temperature (density). The uppermost warm, light water layer (epilimnion) floats over the cooler denser bottom water (hypolimnion). The boundary between the two layers is the thermocline. Deeper lakes (> 10-15m) are thermally stratified from spring to fall. Lake Merced stratifies thermally in spring-fall but the stratification is not stable and breaks down on average every 11 days following strong winds.
- Holomictic (whole mixing) – lake water column mixes top-to-bottom. Condition is usually defined as a "uniform" top to bottom temperature or with wind-based dimensionless numbers such as the Reynold's Number (Re), the Wedderburn Number (W), or the Lake Number (Ln).
- Polymictic (many mixings) – holomixis or near holomixis occurs many times in the spring to autumn period usually following windy days. The mixing is interspersed with periods of thermal stratification during calm sunny days. The frequency of polymictic mixings can vary from every day or two to months.
- WSE – water surface elevation
- Anoxia – a complete lack of dissolved oxygen in the water (DO = 0 mg/L)
- Functional anoxia – DO level < 2 mg/L in the water above the sediments usually means that the sediments themselves are fully anoxic and will release nutrients to the overlying water once oxidants such as nitrate in the sediments are reduced.
- Eutrophic – a productive lake state characterized by abundant algal growth and low water clarity due to a good supply of nutrients like nitrate, ammonia and phosphorus.

Background

Lake Merced; water supply, lake depth and water quality

Lake Merced is by far the largest of the three natural lakes in the San Francisco area. It has the typical shape of a former river-estuary channel; a rounded rectangular basin with fairly steep sides and a long, narrow trench close to the NE shore. It is now closed off from the sea and divided into four sections the largest of which is the 163-acre South Lake. At the baseline water surface elevation of 6 feet, the current maximum depth is about 24 feet. Due to the loss of inflow the lake has lower elevation than may have occurred in the past. Over the last 100 years the inflow of surface and groundwater to Lake Merced has been substantially reduced. The drainage area has been reduced by 50 to 90 percent and groundwater extracted for the drinking supply and golf course irrigation (see Appendix table A). Full restoration of South Lake to its original size and depth (not known) is not feasible at this time.

This report evaluates the effect on the limnology of further increasing the mean depth of Lake Merced by 0.5 to 2.5 feet from the current depth (WSE 6.5 ft. to 8.5 ft., max WSE 9.5 ft.). In particular, the report focuses on the effects of depth on two variables; dissolved oxygen and pH and the variables (algae, water clarity) that control them.

South Lake is listed as an impaired water body under the section 303 (d) of the Clean Water Act for dissolved oxygen and pH. In part the water quality impairments are due to its current depth of 24 feet which is "awkward" in terms of water quality. Deep (> 300 ft.) and very shallow lakes (< 3 ft.) rarely show any depletion of oxygen in the bottom waters. Lakes with depths in between the two extremes are affected by the balance between wind mixing (which can stir oxygen down from the surface) and biological oxygen demand (BOD) from the decay of algae in the deep water and sediments. A second critical factor is when the lake becomes permanently stratified between spring and fall. At this time most of the mixing energy in the water is confined to the surface water layer (epilimnion) and the deeper cooler bottom water (hypolimnion) is relatively udisturbed. The critical depth at which permanent stratification would occur is about 30 to 35 feet in the Bay Area climate. This depth is not within the current predictions for Lake Merced.

In 2011, continuous recording probes were used for the first time to improve the data base. The data showed that mixing occurred on average every 9 to 11 days, depending on the site in the lake. While mixing brings oxygenated water to the deep waters and nutrients up to the surface, mixing is not measured directly by DO and temperature probes. Historically, a water column was considered fully mixed (holomictic) if it was "isothermal" or with a uniform temperature throughout its depth. Physical limnologists, who were usually trained in temperate waters, assumed isothermal conditions were < 2 ^{o}C. In warmer waters, isothermal is probably < 0.5^{o}C. The rate of mixing is not specified under the term isothermal so could be weak or strong. Importantly, for the purposes of understanding DO problems in lakes, isothermal does not mean that dissolved oxygen is also uniform throughout the lake's depth. For Lake Merced, the rate of mixing in summer-fall 2011 was usually insufficient to carry enough oxygen down to offset the biological oxygen demand (BOD) of the sediments created by algal decay. Complete holomixis (top-to-bottom mixing) probably occurred only once in summer-fall 2011 (Fig. 2).

The result was an extended period of low DO in the deeper waters. In 2011 near bottom water DO was above the 5 mg/L criterion for only 5 percent of the period from mid-August to mid-October when conditions were most critical (Fig. 2; Table 1). However, functional anoxia (less than 2 mg/L DO) for several weeks is required in the bottom waters before the sediments release substantial amounts of ammonia and phosphate. In Lake Merced, functional anoxia occurred in 2011 at station LM3 for 34 percent of the time (19 non-continuous days with a longest continuous period being only 4-5 days) in summer and fall. So for much of the time (66 percent), some oxygen was present, albeit between 2 and 5 mg/L. Based on the small changes in ammonia and total-P in the same seasons, the short and intermittent period of functional anoxia does not appear long enough to substantially increase sediment nutrient flux. Nonetheless, some nutrients in deep water were elevated in summer. In addition, nutrients in deep water are always higher than the surface where algae have stripped nutrients for growth. Occasional mixing will transport them to the surface. Thus even with low or no sediment nutrient flux, there will be some internal loading from deeper water.

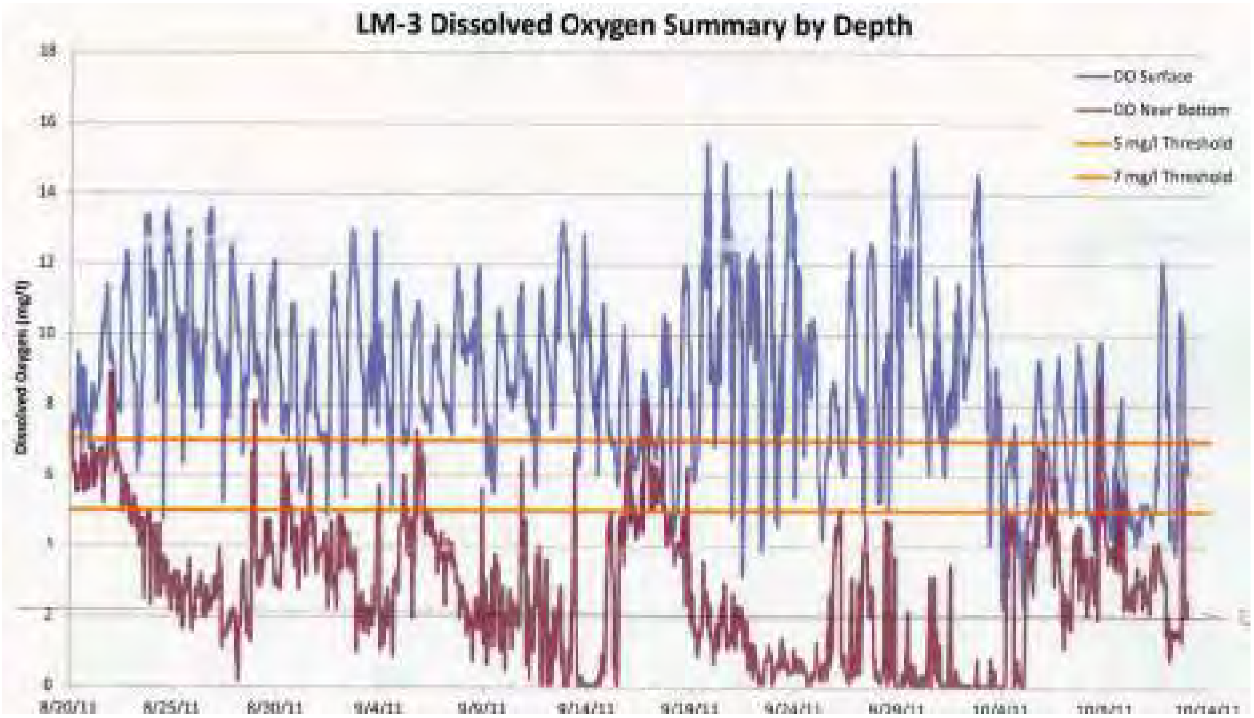

Figure 2. Oxygen depletion in the deeper waters of Lake Merced (South Lake) in summer-fall 2011. Note the prolonged period below the normal criterion of 5 mg/L but relatively short continuous periods of functional anoxia (about 19 non-continuous days at < 2 mg/L). The single obvious top-to-bottom mixing event occurred on September 16th through 19th.

For the cool waters of the moderate-sized, wind- and fog-exposed Lake Merced, increase in depth gives distinctly mixed results for chemical and thermal stratification. An increase in depth will reduce eutrophication by isolating the nutrient-rich sediments from the upper water layers, assisting in reducing events of undesirable high surface pH and reducing periods of low dissolved oxygen in the deep waters. Measurements are available spread out for the last 12 years. Readings of DO were taken in most years between 1997 and 2010 but normally once per year for the critical summer-fall period and not always in the same month. There was a series of years with relatively low water levels (1997 to 2003; water elevation 0 to 3.8 ft.) and a similar period of higher water levels (2004 to 2010; water elevation 4 to7 ft.). Increased depth did reduce DO in deep water (Table 1). The effect was most pronounced in autumn. The bottom DO in September-October 1997 to 2003 was > 5 mg/L 50 percent of the time but only 20 percent of the time from 2004 to 2010. However, no negative effects on algae or water clarity occurred when the incidences of low DO in deep water increased. In fact, any adverse effect due to lower DO in the deep water seemed to have been more than balanced by beneficial effects of deeper water since water clarity increased and nitrate, pH, and turbidity declined (Kennedy-Jenks, 2010). The balance between deeper water effects and those from longer benthic DO are also discussed later.

Table 1
Current water quality and depth relationships in South Lake (Lake Merced) recorded below 15 ft depth at station LM3. 2011 data measured frequently with in situ probes; earlier data taken occasionally.

Time period	**Length of time forDO < below 5 mg/L below 15 feet**	**Length of time for DO below 2 mg/L below 15 feet**	**Comment**
Aug-Oct 2011	5% (2 days)[1]	34% (19 days)[1]	DO usually below 5 mg/L standard but functional anoxia less common
	WSE 0-+3.8 ft	*WSE +4-> +7 ft*	
June-Aug. 1997-2003	38%	50%	Apparent increase[2] in duration of functional anoxia over last 12 years
Sept-Nov. 2004-2009	50%	80%	Increase in lower DO over 12 years

Source: 2011 data from the LM3 probe; 1997 through 2009 data from (Kennedy/Jenks, 2010).

[1] Not continuous. [2] Duration of functional anoxia between the two periods (1997 to 2009) and the 2011 data do not correspond exactly since different time periods are averaged and there are many more measurements in 2011.

Dissolved oxygen depletion is a common concern for regulatory agencies. Alkalinity or high pH (> 8.5) is also typical of eutrophic lakes but is less well studied. In Lake Merced, pH at above the alkalinity standard violations (pH > 8.5) occurred frequently in Lake Merced due to the removal of acidic carbon dioxide on summer afternoons (Fig. 3). Importantly, the lake's range of pH (approximately 7.5 to 9.3) is always on the alkaline side relative to most lakes, never reaching neutrality (pH 7). Since carbonic acid is produced following decomposition in the sediments, lower pH than measured (pH 8) should be found in deep water. For example, another shallow eutrophic lake in California, Clear Lake, Lake County shows many pH values of approximately 7.7 for bottom water in summer. Given the sandy (acidic) drainage soils and the pH of a main water source (rain; pH equilibrium 5.7), more acid water would be expected in Lake Merced. Lower surface pH (~ 8) did occur at night on most days but only during the day during the only chemical holomixis event on October 17th and 18th, 2011. Values of pH > 8.5 may be a natural phenomenon in Lake Merced, but could be exacerbated by eutrophication.

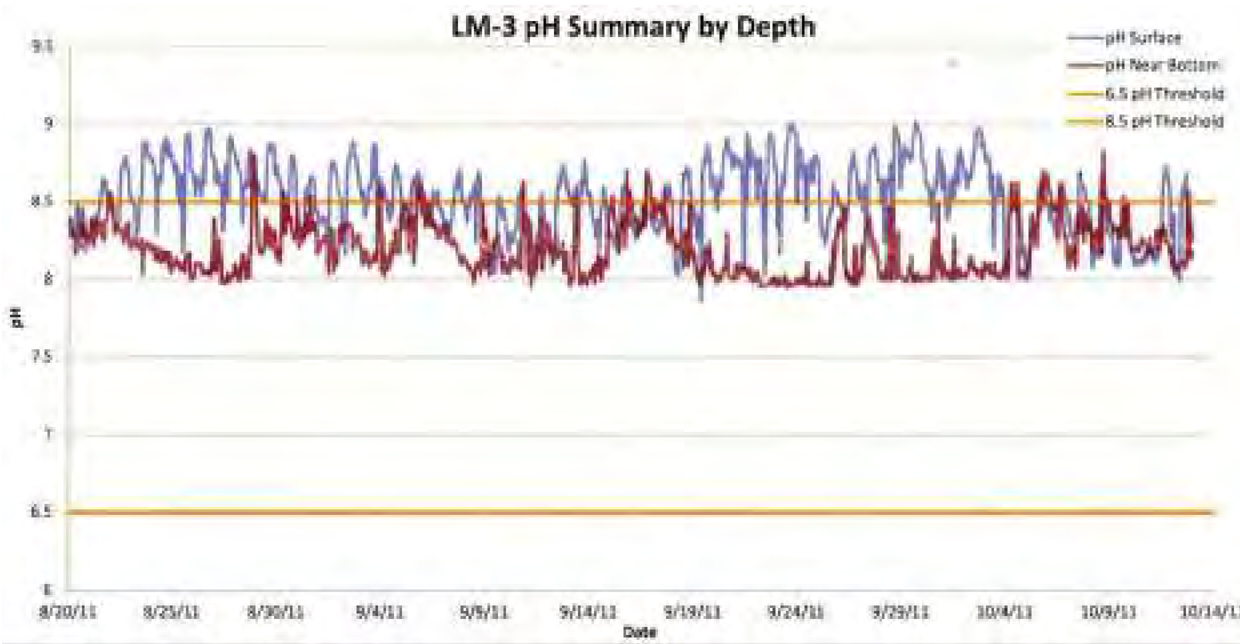

Figure 3. pH variations at the surface and bottom water of Lake Merced (South Lake) in summer-fall 2011. Note the regular excursions above the criterion of 8.5 mg/L during the day but compliance during the complete water column mixing event on September 16th and 17th.

The low DO and high pH in Lake Merced may result partially from its current depth range. Algae have optimal growth under well-mixed conditions with ample nutrients and light. Lake Merced has an ample nutrient supply and good conditions for algal growth because the lake stratifies thermally for one to two weeks, then mixes again.

The Memorandum of Understanding between Daly City and SFPUC set a range of target water surface elevation (WSE) scenarios for the South Lake that include mean depths of 6.5 to 8.5 feet with a maximum high elevation of 9.5 feet. Future annual variations of about 1.4 feet are expected to occur naturally, and are similar to current variation. This range is moderate for natural lakes but may be adequate for biomanipulation if it is instituted for long-term, sustainable lake management. Biomanipulation requires the development and preservation of a band of submerged leafy plants such as pondweed (Potomogeton) or similar native species. In turn, these cannot grow if the autumn water levels drops sufficiently to desiccate them.

The supplementary water would have two sources; summer base flows and winter storm water. Routing these flows to the lake would restore some natural inflow sources and would also reduce flood damage in Daly City. Reconnecting some of the Lake's former drainage area would increase water supply to Lake Merced such that the target elevations could be reached and maintained, but modern street runoff contains more pollutants than the historical storm inflows from the grassland and shrubs that originally covered the Lake's historic watershed. Therefore, the storm water used will be the later (cleaner) flushes. The source of the summer base flow is local drainage which will be cleaned up by proposed treatment wetlands at the upper area of the lake. Additional depth will also increase the size and area of the lake which is often a long-term benefit to the wildlife and other lake users.

LAKE MIXING AND WATER QUALITY

Water depth plays an important role in water quality in shallow, eutrophic lakes like Lake Merced. A much deeper lake would be thermally stratified from spring to fall (monomictic lake). Even if there were oxygen depletion in the deep water, the consequent release of nutrients from sediments would not reach the surface until the fall overturn when the available light is beginning to limit algal growth. A local example is Upper San Leandro Reservoir in the East Bay, which is a much shallower lake that experiences almost daily mixing, supplying ample oxygen to the sediments. Another good example is 20-acre Lake Machado near Long Beach Harbor in Los Angles, which is a former river channel like Lake Merced. Lake Machado is very eutrophic with a bright green color, but is only 2 to 6 feet deep and shows little sign of low DO even on hot summer days.

South Lake currently has a maximum depth of 24 feet, so is neither shallow enough to mix enough oxygen into bottom waters, nor deep enough for nutrients to remain below the level of algal growth. Either option would result in less nutrient flux from sediments to surface water and in less eutrophication (fewer algae, more dissolved oxygen in deep water, and lower pH in the surface water). The recommended increase in depth to 24.5 to 27.5 feet would keep the lake in between these two conditions.

Regardless of the present depth, even a small increase in the depth of Lake Merced would result in less frequent mixing (less polymictic). However, small increases in depth would have only small effects until the depth reached the critical point where thermal stratification becomes continuous from spring to fall (monomictic). As discussed in full later, earlier, an increase to the critical depth for permanent summer stratification accomplished by water level increase alone is not feasible since a WSE of +18 feet would be required. More important to water quality than thermal stratification is chemical stratification, especially for dissolved oxygen. Chemical stratification is much less well understood than thermal stratification because it is a dynamic chemical-physical process while thermal stratification is mostly a physical process only. In many lakes, thermal and chemical stratification occur together, but while thermal stratification is intermittent, chemical stratification is more persistent. The difference occurs because the rate of downward mixing of oxygen is less than the rate of oxygen demand of the sediments and deep water. Recent continuous recording probes in Lake Merced demonstrated weak thermal stratification but much stronger oxygen stratification.

A simple lake model based on the propagation of surface wave oscillations to the sediments was used to show the effects of different lake depths under the proposed scenarios. Sediment stirring was used as a proxy for changes in the flux of nutrients to the water. The changes in nutrients were then modeled to show likely effects of chlorophyll (algae) and water transparency that would occur at the proposed mean and maximum depths. The results were calibrated against the current lake conditions and were expressed in terms of potential algae blooms and water clarity.

MODEL DESCRIPTION

A simple lake model based on mixing depth and the chlorophyll-water transparency relationship was used to estimate the water quality changes that would occur at the new depth. The mixing model used is based on both theoretical energy-mixing distribution with depth and estimates of the wave length and amplitude in Lake Merced The new continuously recording data from in-lake probes were not available previously. The new data allow this model to build on the predictions from previous ones such as that of Michael Deas (Watercourse Engineering, Davis, CA) in the EDAW report (2004). That model for Lake Merced was based on the changes of the slope of the thermocline at various wind speeds (Wedderburn or Reynolds's numbers, EDAW, 2004, page 8). Models based on the Reynolds's number use the ratio of wind-powered mixing to the resistance to mixing as determined by the density difference between the warm, less dense upper water layer and the cooler, denser lower layer. Reynolds's number is specific for the lake's actual wind speed and temperature-depth profile but not for other factors like shape or size. The Wedderburn number is a more complex extension of the Reynolds's number that does take into account some lake parameters such as length and thus the fetch over which the wind blows; the longer the fetch the higher the wave for a given wind speed.

The model used for Lake Merced on this occasion was based on the propagation of mixing energy down each surface wave to the sediments (Horne & Goldman, 1994). This model replaces the wind and density differences with empirical data measured or assumed for the lake; in particular wave length and wave height during windy periods. In large lakes waves vary from place to palce but in small lakes such as Lake Merced these two variables are similar over the 163 acres of surface water. Fully accurate estimates of wave height and length are difficuot to measure but approximate maximum wave height of 30 cm and a wave length of 3 m were estimated from visual observations at the lake in 2012. The oscillation of the water molecules on the surface produces similar, if decreasing, temperature inversions all down the water column. Fewer temperature inversions occur as the water gets deeper and the mixing energy is lost to friction. Temperature inversions cause mixing because they are unstable; cooler denser water is lifted above the surrounding lighter warm water. When gravity reasserts itself the parcel comes crashing down past its equilibrium depth. If that occurs near the bottom a parcel of water will impact the sediments at an angle then bounce up carrying with it sediments and nutrients that otherwise would be locked into the mud. The energy propagation with depth method is more direct and more useful for the purposes of estimating sediment nutrient fluxes in lakes with modest depths like Lake Merced than the 2004 model.

The water parcel oscillations decrease approximately as the log of the wave length. Thus a 30 cm surface wave would be 3 cm at 3 m (one wavelength) and 0.3 cm at 6 m (two wavelengths) and 3 mm at the bottom of Lake Merced if it was 9 m deep. It can be seen that even at its stormy peak, oscillations and mixing energy over the deeper areas of Lake Merced would see little action relative to the furious churning of the surface waters.

There are two kinds of general water motion; waves and currents. Waves are the dominant mixing force since they have a vertical component. Currents are the main method of moving water but have only a small vertical component. The reason for that is that almost all of the wind's energy goes into horizontal motion pushing large volumes of the upper water layers round and round the lake. The lake can be thougth of as a series of separate slabs of water, each a meter or so thick and with a slightly different temperature and density. This Lagrangian Slab concept can be verified experimentally and is useful in determining how mixing energy from current. The surface water slab moves quickest and some of its motion is transferred to the next deepest layer. However, because the Earth is rotating quite rapidly, the Corellis Force causes the horizontal motion of the lower slab to move to the right at approximately 45 degrees (at equilibrium with is only reached in large lakes and the oceans). The next slab moves at another 45 degrees and so on down to the bottom in an Ekman Spiral. Thus water moving with the wind at the surface is eventually balanced by other deeper slabs moving in the opposite direction. The friction between each rotating slab does provide some a small vertical mixing but this is very small in the deeper slabs due to frictional losses as the huge slabs of water slide over each other.

Waves of various kinds provide vertical mixing motion directly and indirectly. The most important is the downwards propagation of surface wave energy. The second is thermocline waves or seiches but these are unimportant in Lake Merced which is not always stratified and only the longer waves (km) mix deep water which the estimated wave length in Lake Merced is 3m. Even with long waves most seiches energy is lost as friction when the wave rides over the sediments in shallow edge water. Langmuir Spirals also mix the lake water and are a combination the engeries of both waves and currents. They can be seen as parallel stripes of foam or detritus on stormy days and are orientated in the same direction as the wind. In Lake Merced as all other waters the energy of Langmuir Spirals this energy is confined to the upper few meters of water and will have no effect on the bottom. A similar more efficient wave energy is that of breaking waves on windy days where parcels of water are ripped from the top of the wave and hurled to the trough. Again almost all of this energy is lost on the surface.

The model used for Lake Merced ignores the energy of Ekman Spirals, breaking waves and Langmuir Spirals since they are very difficult to calculate and are small for small lakes like Lake Merced relative to the downward propagation of surface waves on windy days. The results were calibrated against the current lake conditions using the 2011 detailed temperature probe data from three depths and were expressed in terms of potential algae blooms and water clarity.

MODEL RESULTS

The effects of increasing the depth of the south basin of Lake Merced are shown in Tables 2 and 3. The effects of increases of 0.5 to 3.5 feet on the mixing frequency are shown in Table 2. The present mixing frequency of 11 days was determined empirically from the output of the continuously recording temperature probe deployed in 2011. As the lake depth increased, the mixing frequency decreased because it takes more energy to stir more water. The increases in days between mixing were not linear because the loss in mixing energy with depth is almost logarithmic.

Table 2
Modeled effect of increasing the depth on the frequency of mixing in Lake Merced (South Lake).

	Present[1]	**Scenario A mean**	**Scenario B mean**	**Scenario C mean**	**Scenario C maximum**
Depth increase (ft)	**0**	**0.5**	**1.5**	**2.5**	**3.5**
WSE **(**City Datum, ft.)	6.0	6.5	7.5	8.5	9.5
Water depth (ft)	24	24.5	25.5	26.5	27.5
Depth increase (%)	0	2.1	6.3	10.4	14.6
Mixing frequency	11	12.5	15.0	19.7	25.5

(days)					
Mixing regime	Polymictic	Polymictic	Polymictic	Polymictic	Moderately polymictic

Note: All depth changes are based on the San Francisco City datum which was 0 ft in October 2002. In 2008-2010 the water surface elevation (WSE) in the lake varied seasonally from about 5 to 7 feet.

[1] At this time the precise maximum depth of the lake is not certain but was about 24 feet which is equivalent to the depth when the WSE was 6 feet. Small changes in the maximum depth will not affect water quality predictions based on calculations presented here since they are all relative to each other.

Based on the summer-fall continuously recording probes deployed in 2011 and some assumptions about wave amplitude and wavelength, the additional water will make a noticeable difference in the stratification period. The assumptions for Lake Merced were a typical maximum waver height of 30 cm and a wave length of 3 m. The increase in depth reduces wave-driven swirling on the bottom mud that propagates down from the surface. Bottom stirring will almost halve from 0.1 cm to 0.04 cm (Table 3). The result in the important variable of mixing is an increase in the top-to-bottom water column mixing frequency from every 11 days (current situation) to every 25.5 days (+3.5 feet).

Table 3
Estimated changes in bottom water wave-induced stirring with additional depth for Lake Merced

Elevation/Scenario measured	Water depth (ft)[1]	Wave amplitude at depth (cm)
Surface	0	30
Bottom, Existing	24	0.102
Bottom, Scenario A mean (+0.5 ft)	24.5	0.090
Bottom, Scenario B mean (+1.5 ft)	25.5	0.075
Bottom, Scenario C mean (+2.5 ft)	26.5	0.057
Bottom, Scenario C max (+ 3.5 ft)	27.5	0.044
Calibration	18.8	0.36

[1]The depth estimates are based on the SF baseline at a recent historical low in October 2002. In 2010, lake depths varied between + 6 and + 7 feet from this baseline shown as an average of 24 feet.

Some further support for the concept that increasing depth may improve conditions in Lake Merced can be found in the recent Kennedy-Jenks report (2010). This work shows that a recent increase in water depth (+1.5 ft; 2000 to 2005) resulted in a slight increase in water clarity as measured by Secchi depth. Although the increase was only 8 inches, this is nonetheless an approximately 40 percent improvement over the current water clarity. The recent increased water transparency was not clearly related to nutrients or algae, since these did not change markedly. Nitrate decreased and phosphate increased, with no information given for ammonia. The transparency increase was likely due to less suspended sediment because turbidity declined (Kennedy-Jenks, 2010). A plausible reason is that deeper water allows slowly sinking sediments to fall below the wind-mixed zone and thus cease to contribute to poor lake water clarity. Another possible reason is that the new higher water level results in a shoreline less prone to wind-induced soil erosion.

MODEL CALIBRATION SUGGEST LEAVE THIS OUT FOR NOW: I WILL DO A NEW VERSION THIS WEEK

Temperature effects indicate mixing events and can be detected in the record of the continually recording probes (Fig. 2). The result is a certain number of events over time at various depths. The modeled values are for the fixed depth increases considered (+0.5 to + 3.5 ft) so are down close to the bottom of the lake. However, the in-situ probes were not located at many depths. Good in situ probe records for summer-fall temperatures were at LM-4 located at the surface, 10, 15 and 20 feet down. A temperature spike or trough at the surface may or may not be mixed down to create a signal at the bottom. In general the 0-15 feet probes were located within the mixed layer (epilimnion if stratified) and tended to move together as far as temperature is concened. However, the 20 foot probe was located below the mixing layer for much of the time. When it received at signal from the surface (temperature spike) an empirical measure of mixing can be made. In this case at LM-4, ther were five clear mixing events (temperature spikes at 20 m) over 55 days of summer-fall giving a mixing frequency of 11 days. For the bottom probe at LM-3 at 20 feet there were an average of 7 events over 55 days or every 7.9 days. The theoretical ratio of the calibration depth modeled mixing frequency at the existing 24-foot depth (11 days) to the modeled frequency at 18.8 feet (3.5 days, see Table 2) is 11/3.5 or 3.14. Some measure of how realistically this simple mixing model represents the actual situation can be given by examination of the actual mixing events in two sites in the lake where continuous recording temperature records were made in 2011 (Table 4). For these depths, the empirical ratio of mixing events measured in summer-fall 2011 at 15 feet deep versus 20 feet deep (28/7) is 4.0.

Table 4
Measured and modeled water mixing frequencies in Lake Merced in 2011

Depth (ft)	Mixing occasions detected	Mixing frequency (days)	Method
15	28	2	Measured
10 LM-4	44	1.3	Measured
20 LM-3	6 to 8 (mean = 7)	7.9	Measured
10	N/A		Modleled
20	N/A		Modeled
18.8	N/A	3.5	Modeled
24	N/A	11	Modeled
27.5	N/A	25.5	Modeled

Note: the measurement period was 55 days (mid-August to mid-October, 2011).

Considering the simplicity of the model and the estimates made, the agreement with the measured lake data (ratio = 4.0) and the model (ratio = 3.1) is quite good and adequate for the purpose of predicting water quality changes that would occur if the lake elevation is increased under any of the three scenarios proposed. Allowing for the additional information from the 2011 continuously recording probes, the conclusions in this report are in broad agreement with the previous ones such as those by EDAW (2004) and Kennedy-Jenks (2010).

ESTIMATING EFFECTS OF REDUCED MIXING ON NUTRIENTS AND ALGAL BIOMASS

The concentrations of nutrients in the waters of Lake Merced (Table 5) are similar to many urban waters in the semi-arid West. Biologically available nitrogen is scarce (mean total inorganic Nitrogen [TIN] = 93 µg/L) and biologically available phosphorus is plentiful (mean total phosphorus [TP] = 120 to 200 µg/L). Nitrate and ammonia are readily used by algae but organic N (most of TN here) is refractory or hard to break down and mostly unavailable for algae growth. In contrast, about 80 percent of total phosphorus can be easily converted to biologically available phosphate in hours with the common alkaline phosphatase enzymes present in algae and sometimes in the free water. The enzyme cleaves the phosphate-carbon bond. Organic N can also be converted to ammonia but there is no abundant equivalent enzyme to break the carbon-amine bond of nitrogen. The mineralization of most organic N to bioavailable TIN takes months or years and is far too slow to supply algae blooms that grow in a few days or weeks. Given the very low amounts of bioavailable nitrogen present, limitation of algal growth by nutrients is possible. Chlorophyll is not present in densities that would limit growth by self-shading, although during deep mixing events, growth may be light-limited because some algae will be too deep for sunlight to reach. At other times, nutrient limitation is possible.

For Lake Merced, the model assumes that the less frequent mixing in the deeper lake options would result in relatively less nutrients stirred up from the bottom and consequently less algae growth and eutrophication. The number of days between mixing events indicates the frequency at which nutrients released from anoxic sediments during temporary stratified conditions are circulated up to the illuminated waters and become available to algae. Thus, the mixing frequency approximates to the eutrophication potential.

Table 5
Water quality data for Lake Merced during the dry season

Nutrient	Concentration (µg/L)			Comments
	Mean	Max	Min	
2011 Data				
Nitrate	43	70	19	Very low[1]
Ammonia	50	140	< 50	Low[1]
TIN	93	210	69	Low[1]
TKN (organic-N)	875	1,500	610	Moderate[1]
TN (TKN + nitrate)	~ 910	~ 1,600	~ 630	Moderate[1]
Phosphate	35	120	21	High[1]
TP	120	670	210	High[1]
0.8 TP	96	536	168	
TP 2000-03; Casteel et al., 2005	200			High[1]

Ratios of TIN:0.8TP for Lake Merced and Comparison Values

Lake/Scenario	Ratio of TIN:0.8TP	Comments
Lake Merced	1:7.8	Strong N-limitation
Balanced growth	~ 10:1	No limitation
Lake Superior, Great Lakes	~ 40:1	Strong P-limitation

Source: 2011 data (complete citation), Kennedy-Jenks, 2010

[1] Nutrient level compared to what would be expected for an urban water body

The clarity of lake water is perhaps the most important and visible water quality parameter that impacts the public. Water clarity can be measured by noting the depth to which a white disc (Secchi disc) can be seen. Secchi depths range from a few inches in very eutrophic lakes with algae scums to over 100 feet in very clear blue lakes like Lake Tahoe. In Lake Merced there appear to be two mechanisms that decrease light penetration into the water: suspended inorganic sediments and algae. Light absorption by water is reduced by algae (chlorophyll) and is related in the model to water clarity. Water clarity due to sediment is modeled by difference. Lake Merced has poor water clarity (2 feet) but has seen a recent small increase in water clarity probably due to improvements in watershed sediment control. The change could also be due to the additional few feet of water added (decreased mixing) or increases in shoreline submerged vegetation (reduces wave-generated sediment suspension).

The decrease in light attenuation in water is non-linear so in more eutrophic lakes the human observer on the shore has difficulty in seeing an increase in water clarity even when chlorophyll declines substantially (Fig.4). Once a certain threshold is reached, however, relatively small changes in the amount of algae produce observable benefits to the shoreline observer. The lake water is at least potentially nutrient-limited, with nitrate being the limiting nutrient – at least in terms of biologically available nutrients. The effects of decreased nutrients caused by lower sediment mixing due to higher water levels should have an effect on eutrophication, algae, and water clarity. The changes in nutrients caused by simple changes in mixing are assumed to have a linear relationship. The relationship of nutrients to algae, however, will not be one to one (nitrogen released all going to algal growth) since there is considerable inefficiency in converting nutrients in the water to algal biomass.

The estimates of algae (chlorophyll) and water clarity modeled from the changes in mixing were calculated in a simple Excel spread sheet and summarized in Tables 6a and 6b. For Lake Merced, the empirical data shows the average summer chlorophyll *a* was 30 µg/L (2000 to 2003, Casteel et al., 2005) and 27 µg/L (range 4.7 to 100; Kennedy-Jenks, Jan 2010). For this analysis, 30 µg/L was used.

For the +2.5 feet WSE increase, an estimated decrease of 40 µg/L is TIN is predicted with a resulting decrease in algal chlorophyll a of 4.5 µg/L (Table 6a). The decrease in chlorophyll a is based on measured changes in chlorophyll in Lake Merced with measured changes in TIN. This is described further in the Increase in Algae Due to Storm Water Inflow section below.

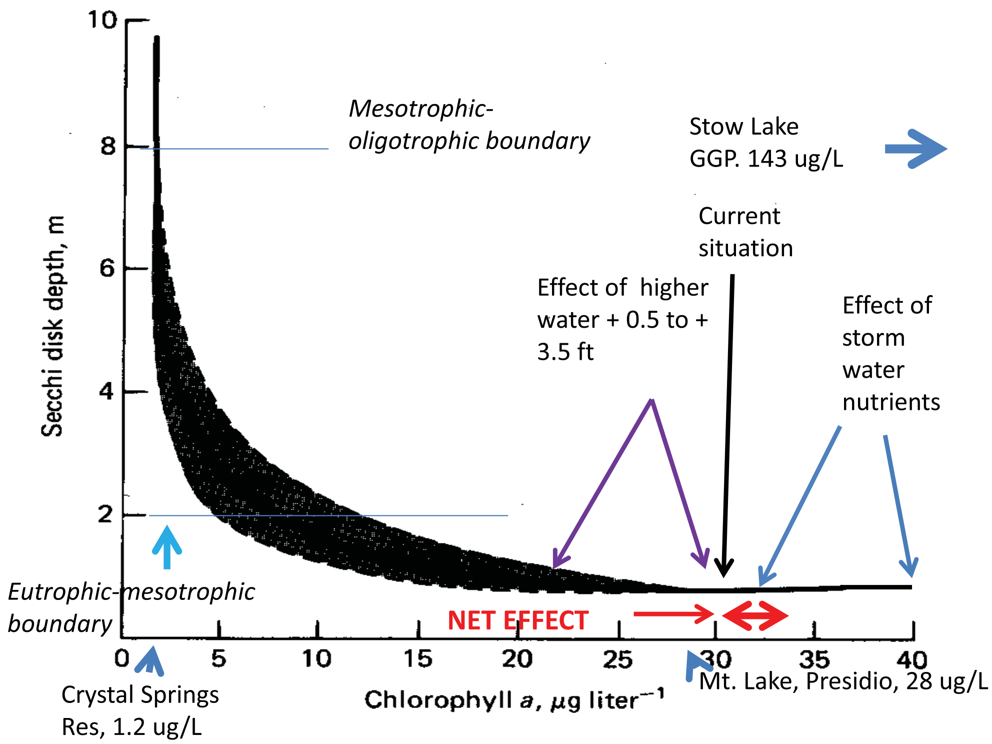

Figure. 4. Relationship of algae as chlorophyll and water clarity as Secchi depth for Lake Merced at proposed depth increases (+0.5 to + 3.5 ft.). Also shown is the location of three other San Francisco Area lakes on the chlorophyll-water clarity curve.

Table 6a
Estimates of effects of a range of increased depths on chlorophyll for Lake Merced

Elevation/Scenario	Water depth (ft)[1]	**Polymictic Index (2011 = 100)**	**Estimated TIN in mixed water column (µg/L)**	**TIN decrease µg/L**	**Estimated chl *a* µg/L at surface**	**Chl *a* decrease µg/L**
Surface	0		90	0	30	
Bottom, Present	24	100	90	0	30	
Bottom, Scenario A mean (+0.5 ft)	24.5	88	79	11	28.5	1.5
Bottom, Scenario B mean (+1.5 ft)	25.5	73	66	24	26.7	3.3
Bottom, Scenario C mean (+2.5 ft)	26.5	56	50	40	24.5	5.5
Bottom, Scenario C max (+ 3.5 ft)	27.5	43	39	51	23.0	7.0

Note: The mean Secchi depth for Lake Merced in 2009 was approximately 2 feet and corresponded to a dry season algal chlorophyll *a* value of 30 µg/L (2000 to 2003 data). This is similar to the long-term data set [chlorophyll *a* 27 µg/L & Secchi depth 1.8 ft (1997 to 2008)]. The TIN in summer is 90 µg/L (Table 7).

The various depth increases produced estimated chlorophyll *a* reductions of up to 7 µg/L (about 23 percent). A maximum decrease of 23 percent in algae would result in only a small decrease in BOD in the sediments since not all algae sink as complete cells. Thus the maximum increase in depth would not be a cure for the bottom water low DO episodes.

Table 6b
Estimates of effects of a range of increased depths on water clarity for Lake Merced

Elevation/Scenario	**Estimated chl *a* µg/L at surface**	**Estimated Secchi depth (ft)**	**Eutrophication estimates**
Surface	30	2	Eutrophic, no visible changes
Bottom, Existing	30	2	Eutrophic, no visible changes
Bottom, Scenario A mean (+0.5 ft)	28.5	2	Eutrophic, no visible changes
Bottom, Scenario B mean (+1.5 ft)	26.7	2	Eutrophic, no visible changes
Bottom, Scenario C mean (+2.5 ft)	24.6	2 to 2.3	Eutrophic, possible slight increase in water clarity

Bottom, Scenario C max (+3.5 ft)	23.0	2 to 2.3	Eutrophic, possible slight increase in water clarity

In terms of water clarity, no effect can be expected even though chlorophyll is estimated to drop with increased depth. There is no water clarity improvement in proportion to lower chlorophyll levels at these concentrations since the curve of chlorophyll with clarity is flat at this algae concentration (Fig 4). Because of the shape of the chlorophyll/water clarity relationship (Figure 1), no discernable change in water clarity occurs over the chlorophyll *a* range of about 16 to 38 μg/L. It is unlikely that anyone could see such a small change and Secchi depths of 2 to 2.3 feet are indicative of poor water quality. A goal for Lake Merced would be 6.5 feet which is the threshold of the eutrophic-mesotrophic conditions.

The photic zone or layer where the light intensity is suitable for photosynthesis can be defined as that greater than 1 percent of incident light. By convention, the zone below 1% of incident surface light is too dark for photosynthesis (Horne & Goldman, 1994) and is the called the aphotic zone. The photic zone depth is not known for Lake Merced but can be approximated as 2.3 times the Secchi depth (2 feet) and is thus 4.6 feet. Algae grow well in the upper 3 to 6 feet of water unless they were stirred down into the deeper dark water bellow. However, almost 80 percent of the lake water column of 24 feet below the photic zone is thus too dark for algae growth. The lake mixes fully every 11 days and probably down to about half way (10 to 13 feet) every windy afternoon. Thus, the algae would spend much of the daylight hours in the dark with reduced efficiently of growth. This is the likely reason that there are not more algae in Lake Merced. If the lake did not mix or was shallow enough for mixing only in the photic zone, chlorophyll levels would probably be 5 to 10 times as great.

FURTHER DEPTH INCREASES

Previous small depth increases (few feet from 2002 to present) resulted in lower turbidity (Kennedy-Jenks, 2010) and this report indicates some possible, if small, further improvement in algae reduction and water clarity increase if a further few feet of depth are added. A common management practice for eutrophic lakes is dredging, which would add about 3 more feet to the lake depth. The relative improvement would be small and similar to that found in the past. In contrast, the removal of nutrient-rich sediments alone would improve water quality considerably but would soon be negated unless the inflowing water was low in nutrients. Due to the cost of dredging per unit area and the size of Lake Merced, dredging of substantial areas does not seem likely in the near future.

An improvement in water quality in Lake Merced noticeable to the public following the proposed up to 3.5 feet depth increase would require an active management such as aeration-mixing. This technique is an eminently suitable solution for Lake Merced and would almost guarantee compliance with the pH and dissolved oxygen standards. The lake water is unusually cool due to its location by the Pacific Ocean, so mixing would be energy-efficient. Although Lake Merced is stratified in summer-fall, the cooler surface water (typically 19-20^{o}C) is less dense than, for example, a similar lake in the East Bay such as Upper San Leandro Reservoir (USL ~ 22-23^{o}C; Horne et al., 2003). Likewise, the deep water temperatures are also warmer in Lake Merced (17-18^{o}C) than USL (13-15^{o}C, upper hypolimnion). The temperature difference for bottom and top water layers is thus about 8.5^oC for USL but only 2^oC (max is not known since fall bottom water temperature probe data for summer-fall is not yet available). It is easier to mix water layers with similar temperatures. However, the temperature difference of 6.5 degrees is not quite as large as the density difference since two warm water layers are harder to mix that two cooler layers with the same temperature difference between layers.

To replace summer polymixis-holomixis with a thermally stratified monomictic lake would require a depth increase of at least 12.5 feet over the present conditions. However, even then, the newly formed hypolimnion would be so small that it would soon become depleted in oxygen. To ensure high-quality water in a monomictic Lake Merced would require installation of a Speece Cone type oxygenation system.

EFFECTS OF INCREASED NUTRIENT LOADING FROM MAKEUP STORM WATER ON ALGAL BIOMASS

At present, Lake Merced is virtually a terminal lake with no outflow to the sea. Thus, any nutrients entering the lake will either dilute or concentrate nutrients in the water depending on their concentration. Since the lake receives no surface runoff in the dry season, apart from an unknown amount of groundwater, the amount of nutrients present in the lake in late winter and early spring will determine the amount of algae that will grow between March and November.

Increased water flow to the lake is needed to increase its depth. The additional inflow brings with it nutrients and, unless treated, storm water nutrients could increase undesirable eutrophication. On average, storm water in winter 2012 contained moderate amounts of nutrients; median TP 170 µg/L, Nitrate-N 310 µg/L, ammonia-N 150 µg/L (thus TIN = 460 µg/L; Table 7). Base flow nutrients were also higher in the storm water canal than lake base flow values (Table 7) but only TIN (mostly nitrate) was considerably greater – 3,720 µg/L (base flow) versus 95 µg/L in the lake. The ratio of storm water N:P using (0.8 x TP)/TIN was 3.4 and indicated N-limited water in terms of potential algal growth. In comparison, Lake Merced water at this time had an almost identical TP concentration (150 µg/L) to storm water (170 µg/L TP) but only about one-fifth of the TIN level of the incoming storm water. This is not surprising since Lake Merced is strongly TIN-deficient and TP-rich, relative to many U.S. waters located in cooler, wetter climates. Thus incoming storm waters were potentially biostimulating and could increase eutrophication.

Table 7
Summary of nutrients in storm water, base flows, and Lake Merced in winter-spring 2012

Water Source/Body	TP	Nitrate	Ammonia	TIN	0.8 TP/TIN
Storm flow	170	310	150	460	3.4
Storm water canal base flow	260	3,600	120	3,720	17.9
Lake water	150	40	50	90	0.8
Lake water base flow	130	45	50	95	0.9
Lake water premier flush	170	30	50	80	0.6
Storm water premier flush	1,600	1,100	970	2,070	1.6

Note: Median values. TIN = Total Inorganic-Nitrogen (nitrate + nitrite + ammonia). Data from recent surveys reported in full elsewhere.

Under certain conditions, here defined as the "premier flush" the concentrations of both TP and TIN in the storm water increases to 12 (TP) and 22 (TIN) times the concentrations in the lake water (Table 7). This flush is important because it contains higher nutrient concentrations and can be conveyed to the ocean with the existing pipeline. Under some circumstances it will be possible to pass this premier flush water to the ocean and use the second flush of much cleaner water to raise the level of Lake Merced and also to flush out salts that increase alkalinity and pH. Even though the volume of storm water is relatively small (~ 20%) compared with that of the lake at the time of winter storms, the potential input from the premier flush may increase nutrient concentrations in the lake. Algae can use either nitrate or ammonia, so TIN is a convenient summary of the eutrophication effects of added storm water. In any event, ammonia arriving at the lake would probably be rapidly oxidized to nitrate before uptake since winter algal growth is limited by the weak sunlight. The TP from the premier flush would be less likely to have an effect, possibly because the overall amount would be less and 65 percent of the TP in recent storm water was present as particulate matter (1,600 minus 560 is 1,040 µg/L) rather than the soluble phosphate form. Particulate matter would sink to the bottom in the lake and not necessarily affect free water, especially under the fully oxidized winter conditions.

Over winter, the nutrients in Lake Merced build up due to releases from the sediments, groundwater and any surface water inflows, as well as direct precipitation and dust on the lake surface. As winter turns to spring, the nutrients begin to fall as algae grow and use them up (Table 8). In particular, TIN reached 120 µg/L on January 23rd, 2012 then fell to 40 µg/L by March 13th (Table 8). Using this empirical data from late fall to spring 2012 (Table 8), a maximum decline of about 80 µg/L of TIN (120 minus 40 µg/L of nitrate + ammonia) occurred. Since nitrogen is the potential limiting nutrient for algal growth, it is likely that the 80 µg/L of TIN taken up became incorporated into phytoplankton during the "spring" blooms of algae. The terms spring, summer, and fall phytoplankton blooms were coined by temperate zone limnologists and in lower latitudes the spring bloom is often a late-winter growth. In addition, although algal growth is low in winter due to low light, there is sufficient illumination for some growth and algae can take up some nutrients and store them for later use.

Table 8
Changes in nutrients in the lake and in storm water measured over winter in Lake Merced in 2012

Nutrient (units ug/L as N or P)	**1/20**	**1/23**	**2/29**	**3/13**
Lake				
TP	150	140	110	100
Nitrate-N	20	70	20	10
Ammonia-N	50	50	50	30
TIN	70	120	70	40
Storm water				
TP	620	170	360	180
Nitrate-N	1,100	210	260	580
Ammonia-N	1,100	50	210	170
TIN	2,200	260	470	350

Increase in algae due to storm water inflow

The average increase in chlorophyll from wet (winter) to dry (summer) season over the years is 11 µg/L (30 minus 19 µg/L, Kennedy-Jenks, 2010) and the average uptake of TIN in early spring was described in the previous paragraph to be 80 µg/L. Thus 1 µg/L chl is grown by the decrease of 7.3 µg/L TIN (80/11). This value can be used to predict the amount of algae that will grow given a known amount of TIN added in storm water. The 1 to 7.3 relationship is not a directly causal relationship since it was empirically derived and accounts for direct uptake of TIN for algal growth but also the losses of algae by sinking to the bottom, grazing of algae by zooplankton at the time and any parasitism that may have occurred possibly due to chytrid fungal attacks.

The detailed calculations to predict the effects of various volumes of storm water needed to give +0.5 to +3.5 feet in the lake were made using an Excel spread sheet and are summarized in Table 9). An example for +2.5 feet is shown below. The calculation gives the potential amount of TIN added in storm water. In actual conditions some of the TIN added with each storm will be taken up by algae and so not show up in the water as a cumulative sum of TIN.

For a proposed water elevation increase of 2.5 feet over a surface area of 163 acres, the increase in volume is approximately 502×10^6 L. The mean concentration of TIN in recent storm water was 460 µg/L. Thus, the storm water inflow adds approximately 230×10^9 µg TIN.[1] The lake winter volume without storm water is 2.6×10^9 L and contains 90 µg/L TIN, or a total of 234×10^9 µg TIN.

The new TIN concentration at the end of the winter (assuming no TIN uptake during winter darkness) results from the mixing of the sum of the inflowing TIN and that in the lake divided by the sum of the volumes of the inflowing storm water plus the lake water. This is (230 µg + 234 µg) $\times 10^9$/(0.502 L + 2.6 L) $\times 10^9$, or approximately 150 µg/L TIN for final lake water TIN concentration (again assuming that no algal uptake occurred). Without storm water, as at present, the lake concentration of TIN is 90 µg/L at the end of winter (Table 7).

Thus. the increase in TIN by the end of spring due to the addition of enough storm water to increase the lake level by 2.5 feet is approximately 60 µg/L (150 minus 90). Given the TIN-chlorophyll relationship established empirically above (7.3 µg/L TIN = 1 µg/L chl), the predicted increase in algae due to the storm water nutrients is 8.2 µg/L (60/7.3) measured as chlorophyll *a*. The results for the other depths are shown in Table 9

Table 9
Effects of storm water nutrient inflows to Lake Merced with winter 2011-12 nutrient concentrations

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[1] 502×10^6 L water * 460×10^{-6} µg TIN/L water = 230×10^9 µg TIN

Scenario	Additional volume of water added (L x 10^6)	Amount of TIN added (µg x 10^9)	Amount of TIN present before storm (µg x 10^9)	Final TIN concentration at end of wet season (µg x 10^9)	TIN increase (µg/L)	Estimated Chl change (µg/L)
Scenario A mean (+0.5 ft)	99.9	46	234	104	13.7	1.9
Scenario B mean (+1.5 ft)	300	138	234	128	38.3	5.2
Scenario C mean (+2.5 ft)	500	230	234	150	59.7	8.2
Scenario C max (+3.5 ft)	700	322	234	169	78.5	10.7

NET EFFECTS OF DECREASING ALGAE DUE TO DEEPER WATER AND INCREASES DUE TO ADDITION OF NUTRIENTS IN STORM WATER

The net effects of the two opposing effects of deeper water (less mixing) and additional storm water nutrients are shown in Table 10. Continuing with the example of +2.5 feet used above (Scenario C), an increase of 8.2 µg/L chlorophyll due to the storm water nutrients (Table 9) can be compared with the decrease of 5.5 µg/L (30 – 24.5) produced by decreasing lake mixing and sediment nutrient fluxes taken from Table 6a. The increase of 8.2 µg/L due to increases in TIN for Scenario C would be partially balanced by a decrease of 5.5 µg/L chl due to the beneficial effects of a deeper lake giving a net increase of 2.7 µg/L chl or an increase of 9 percent in algae.

Table 10
Estimated *net* effects of increases in water depth and storm water nutrient inflows (TIN = 460 µg/L) to Lake Merced

Scenario	Chl change due to water depth increase µg/L	Chl change due to storm water addition µg/L	Net Chl change due to water depth increase with storm water µg/L & (%)	Net chl µg/L	Net change in Secchi depth cm (%)
Scenario A mean (+0.5 ft)	-1.5	+1.9	+0.38 (1.3%)	30.4	0
Scenario B mean (+1.5 ft)	-3.3	+5.2	+1.9 (6.5%)	31.9	0
Scenario C mean (+2.5 ft)	-5.5	+8.2	+2.7 (8.9%)	32.7	0
Scenario C max (+3.5 ft)	-7.0	+10.7	+3.8 (12.5%)	33.8	0

Note: Values of increases and decreases in chl for various depths from Tables 6a and 9. No visible change in water clarity (Secchi disc depth) occurs with small increases in chlorophyll because the water is optically saturated at chl > 30 µg/L at about 100 cm. Decreases below approximately 30 µg/L do produce small increases in water quality. Decreases below 15 µg/L chl begin to show non-linear increases in water clarity.

CALCULATION OF THE DECREASE IN STORM WATER NUTRIENTS REQUIRED TO GIVE DEFINED IMPROVEMENTS TO LAKE WATER QUALITY

The basis of the TMDL regulations is to reduce inflowing nutrients to meet a goal in the lake water quality. For example, it might be desirable to turn a eutrophic recreational lake into one with a mesotrophic state. These calculations were made for Lake Merced using a simple Excel spread sheet and are summarized in Table 11. The model indicates that any watershed method(s) that would result in no effect value for chlorophyll (< 1 µg/L change) would need to decrease storm water TIN to 360 µg/L. A TIN concentration of 360 µg/L needed to keep the lake at the chlorophyll level found in the past decade (less than 1 µg/L increase) could potentially be achieved through watershed BMPs, a nitrogen-stripping system such as wetlands, or a combination of the two. However, nitrate-removal wetlands work best at warmer summer temperatures so would need to be quite large to work in winter when denitrification is relatively inefficient (50 mg NO_3-N/m^2/d compared with values of 500 mg NO_3-N/m^2/d in summer). Various BMPs including limiting the over-use of N-fertilizers on large areas could assist in this reduction. However, the model predicts that no reduction in TIN in storm water would result in average chlorophyll increase in the lake of only an average of 2 µg/L or 7 percent above present. This would not make a visible difference to the water clarity at levels approximating 30 µg/L.

As has been found in many lake restoration projects, the inability of even large reductions in inflowing nutrients in storm water to decrease algae in the lake is due to the internal loading of nutrients from the sediments in summer which is not influenced by winter inflow except over very long time periods. Thus, not too much can be expected in terms of reduction of TIN by using BMPs in the watershed. However, one outstanding success has been the elimination of very dense seaweed (Ulva) growths in Newport Beach Harbor by a combination of N-removal wetlands (IRWD, Irvine; Horne, 2003a.,) and BMPs in nurseries (Horne, 2003b).

Table 11
Concentrations of TIN in storm water needed to give certain desirable levels of algae, expressed as chlorophyll

TIN µg/L	Depth increase Option				Mean of all depth increase
	+0.5 ft	+1.5 ft	+2.5 ft	+ 3.5 ft	
460 (current storm water)	30.4	31.9	32.7	33.8	32.2
360 (cleaner storm water)	29.9	30.5	30.5	30.9	30.4

Note: The TIN in the lake water is assumed to remain constant at the 2012 level of 90 µg/L. Storm water in winter 2011-12 contained an average of 460 µg/L TIN.

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APPENDIX

Table A-1. Limnological data for Lake Merced.

Parameter	**US units**	**Metric units**
Normal pool (WSE + 6 ft above Oct 2002 SF datum)		
Area, A	163 acres	ha
Depth max z_{max}	24 feet	7.3 m
Depth mean z (estimated from bathymetric survey on 26 Jan 2006)	13.2 feet	4.0 m
Volume, V 700MG x 3.07	2,150 acre-feet	2.6×10^{9}L
Maximum width	Ft	m
Maximum length	Ft	m
Maximum fetch, dam to inflow	Ft	m
Inflow surface & ground water (all 4 lakes) 173-371 MG/y	531-1,139 af	
Hydraulic residence time (modern)	1.9-4 yrs	
Aquifer extraction, modern 3285 MG/y	10,085 af	
Possible total inflow (original = 0.66 x modern extraction + modern inflow)	~ 11,000 af	
Possible hydraulic residence time (original)	Few months	
Drainage area, original 2176-5248	6320 acres	ha
Drainage area, modern	~ 600 acres	
Ratio, reservoir area: original drainage area	1:39	
Eutrophication prediction base on original ratio	Mesotrophic	
Ratio, reservoir area: modern drainage area	1:4	
Eutrophication prediction base on ratio	Oligotrophic	
Chlorophyll a, mean	30 µg/L	
Secchi depth transparency, mean	2 ft	60 cm

Calibration and validation of the model

Calibration. Mixing events can be detected in the record of the continually recording temperature probes (Fig. 2). During a mixing event, a temperature change at the surface is propagated down. More vigorous storm mixing gives larger waves and shows up deeper than gently surface wave mixing. The result is a certain number of events (spikes in the temperature record) over time at various depths. The depth increases proposed for Lake Merced (+0.5 to + 3.5 ft) are equal to total depths of 24 to 27.5 feet. Good *in situ* probe records for summer-fall 2011 temperatures were from the surface, 10, and 20 feet down LM4 and surface and 15 feet (near-bottom) for LM3. Surface data cannot be used for mixing at depth so the best data sets were 20 feet at LM4 and 15ft at LM3. Since the effects of deeper water column mixing were the subject of most interest, the calibration number was taken as the clearest deep value the 20foot set from LM4. At this depth, there were five clear mixing events (temperature spikes at 20 m) over 55 days of summer-fall giving a mixing frequency of 11 days (Fig. 2). This value of 11 days at 20 feet was used to calibrate the model for all depths.

Validation. The available depths for validation of the model were those not used in the calibration; the 10feet depth from LM4 and the 20 foot set from LM3. Note that since the model is calibrated from an actual lake mixing event (20 feet at LM4), it is not a fully independent model based only on the first principles of water motion. The modeled mixing events were compared with those from the two depths available. For the 15foot LM3 data set there were about 200 discernible spikes, 28 moderate ones, and six major events. Taking only those 15foot depth temperatures spikes that were matched with surface temperature spikes and limiting events to greater than 0.5^{o}C gives 18 events or a mixing frequency of just over 3 days (Table 4). The 10 foot report at LM-4 is more chaotic, as would be expected for near surface waters, but 44 events were recorded over 55 days giving a mixing event every 1.3 days (Table 4).

Table 4

Model validation: measured and modeled water mixing frequencies in Lake Merced in 2011. The measurement period was 55 days (mid-August to mid-October, 2011).

Depth (ft)	Mixing occasions detected	Mixing frequency (days)	
		Measured	Modeled
10 ft LM-4	44	1.3	1.0
15 ft LM-3	18 minor	3.1	3.3

The comparison of the measured and modeled values is shown in Table 4. Considering the assumptions made and the calibration using lake data, the agreement between modeling and measured values is adequate for the purposes of predicting the effects of small percentage increase in water depth. Allowing for the additional information from the 2011 continuously recording probes, the conclusions in this report are in broad agreement with the previous ones such as those by EDAW (2004) and Kennedy-Jenks (2010).

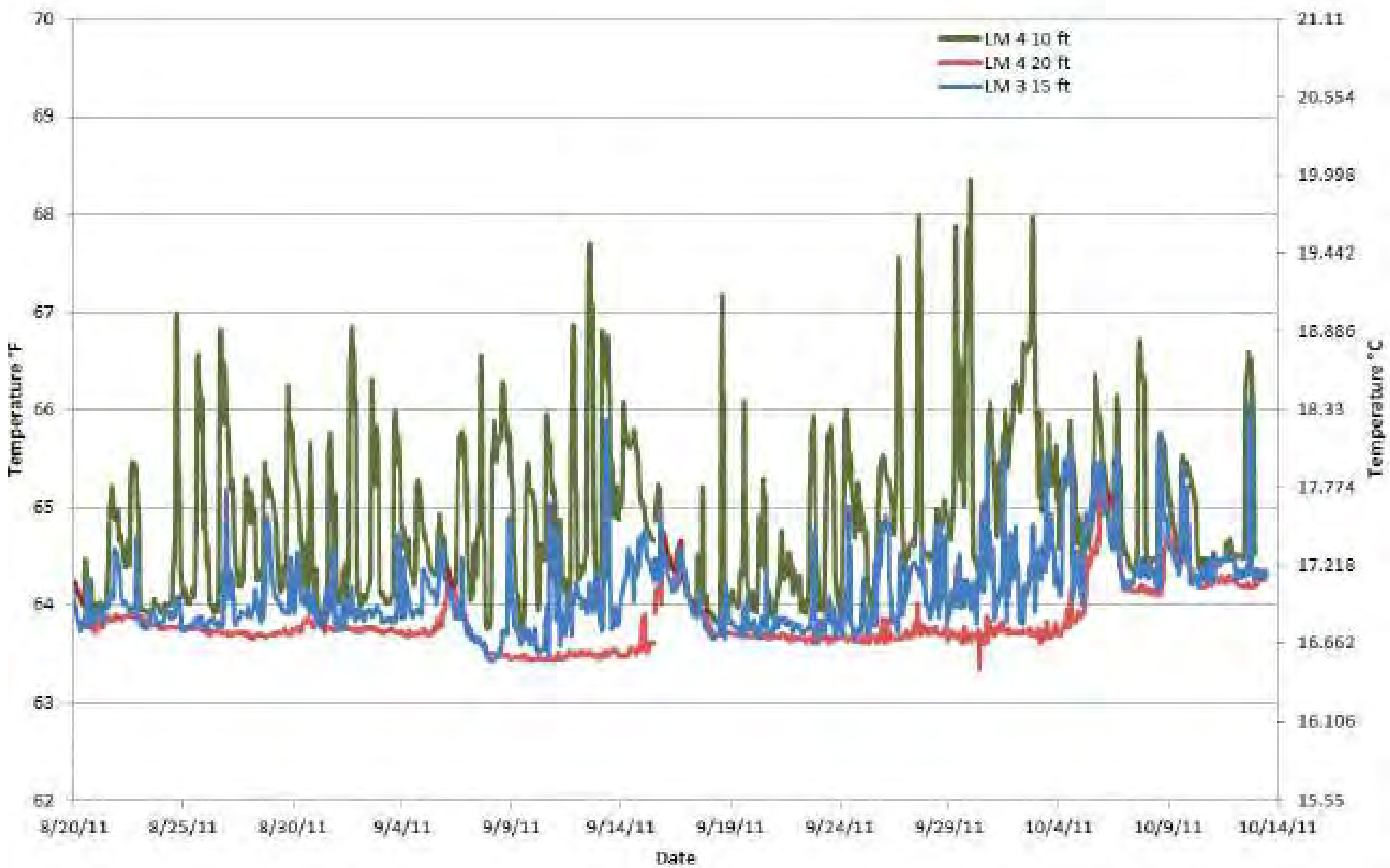

Figure 2: Mixing events shown by temperature probes Aug-Oct 2011

Memo to: Josh Ferris, ESA & Tom Hall, EOA
From: Alex Horne
Re: **ACIDITY AND ALKALINITY (pH) IN LAKE MERCED, SAN FRANCISCO IN RELATION TO EXCEEDENCE OF BASIN PLAN STANDARDS**
Date: First draft 3 July 2012

SUMMARY

The pH of surface water layers in Lake Merced frequently exceeds the Basin Plan maximum of pH 8.5. Based on the lake's moderately high alkalinity (x = 172 ppm; range 136-230), the equilibrium pH of the Lake Merced water can be predicted empirically as about 8.5. The actual daily average pH in September 2011 was 8.45 with an average daily minimum of 8.2 and an average daily maximum of 8.7, thus corroborating the predictions based on alkalinity. September 2011 has the most detailed data set gathered using *in situ* probes and is a typically a month of frequent blue-green algae nuisance blooms. In addition, occasional measurements of pH over the last 40 years also average ~ 8.5. As is common in eutrophic lakes (L. Merced chlorophyll *a* mean ~ 30 ug/L), algal photosynthesis dominates the daily pH fluctuations and cause most pH values above 8.5. Due to the buffering effects of the alkalinity, pH fluctuations driven by photosynthesis in Lake Merced were small relative to other lakes. In September 2011 the average diel change in pH was only 0.5 while most eutrophic lakes show twice this value. However, because even the small increases occurred on a higher base pH level than many other lakes, the resultant pH often exceeded current Basin Plan standards.

The alkalinity in Lake Merced has an unusual history. The lake was mostly likely once a brackish water estuarine channel in summer (~ sea water alkalinity?), a storm-flushed channel during winter storms (low alkalinity), a dammed drinking water storage reservoir (low alkalinity) and now a terminal lake with a long water residence time (moderately high alkalinity). All terminal lakes eventually have high alkalinity and high equilibrium pH and this may explain the current moderately high baseline pH in Lake Merced. The highest pH values (9.1) in Lake Merced were not balanced by low values (7.0 -7.5) as would be expected for a lake with a watershed dominated by sandy lightly-buffered soils. Poorly buffered waters typically show large fluctuations in pH but with expected low values well below the neutral pH of 7. Alkaline base ions are accumulating over time although this is more evident over the last 50 years in the more isolated North and East Lake basins. Regional alkalinity variations explain differences in pH standards in various states in the US, some of which recommend the same pH range (6.5-8.5) while others use 6.0-9.0 – a standard with which Lake Merced would generally be in compliance.

One possible solution to the current higher pH excursions and baseline alkalinity in Lake Merced is a large reduction in chlorophyll by substantially reversing eutrophication. To achieve the pH standard of 8.5 from an average base of 8.2 would require halving current chlorophyll concentration assuming that would halve the photosynthetic rate. Due to hysteresis effects, an algal decrease of that magnitude may be infeasible in a shallow lake with an urban drainage and legacy nutrient pollution in the sediments. An alternate solution would be to increase the flow of low-alkalinity fresh storm water when appropriate to dilute and flush out higher alkalinity water lying near the lake bed. The solution is ecologically attractive since it restores some of the natural original hydrology.

ACID AND ALKALINITY pH IN LAKE MERCED

The pH of the surface water layers in Lake Merced sometimes exceeds Basin Plan standards (max pH 8.5) while bottom waters rarely do (Fig. 1). High pH events (> 8.5) average about 6 hours and range from an hour or so to an entire day. High pH occurs on almost every day in summer and fall and has been similar for the last 40 years (Fig 2). Although high pH occurrences are common in eutrophic lakes in the later morning and early afternoon, the frequency, duration and temporal patterns of high pH found in Lake Merced are not in line with the lake's eutrophic state and algal abundance (chlorophyll *a*: $\bar{x}$~ 30 ug/L). Typically much greater high values in the day and lower pH values at night or on cloudy days would be expected (Straskraba, 1986).

The pH or the abundance of acidic hydrogen ions is controlled by several variables but in moderately productive and eutrophic lakes a daily cycle occurs in the surface waters with highest pH in the day and lowest at night. The best explanation for the observed cycle is algal photosynthesis. When algae photosynthesize two processes occur both of which increase pH. The first process is the uptake of CO_2, carbonate, bicarbonate or carbonic acid. The process is shown below:

$$nHCO_3^- + nH_2O \rightarrow (CH_2O)n + nO_2 + nOH^-$$

[Calcium bicarbonate + water → carbohydrate (cell contents) + hydroxide ion (alkaline)]

The other carbonate reactions involving carbonate (CO_3, also alkaline hydroxide ion production) and carbonic acid (H_2CO_3, neutral products) are not important quantitatively under normal lake pH conditions since their concentrations are small compared with bicarbonate. Other ions may affect the overall lake alkalinity. However, the ratio of hardness (essentially carbonate-bicarbonates) to alkalinity (total bases) is almost unity (172: 180) in Lake Merced indicating that the carbonate-bicarbonates dominate the alkalinity discussed earlier. Thus other bases can be ignored.

The second process affecting pH is the direct uptake of acidic hydrogen ions (H^+) in photosynthesis although this is less easily expressed in simple equations. The net result is that high rates of photosynthesis will elevate pH in lakes, especially in the most sunlit periods 10-4 pm. It is important to note that the rate of photosynthesis, not the amount of algal biomass is important in pH elevation. If some other factor such as light, lake turbidity, mixing or nutrient stress depresses photosynthesis, pH elevation will be muted regardless of the chlorophyll concentration. This was obvious during a mixing event in Lake Merced on 16-19 September 2011 when surface water pH dropped considerably relative to more thermally stratified conditions (compare figs. 1 & 3). It is important to recall that changes in pH due to addition or subtraction of CO_2 do not change alkalinity.

Strictly, the rate of morning photosynthesis sets the degree of pH change but since this is not measured very often, the amount of chlorophyll is used as a surrogate for photosynthesis. Photosynthesis is controlled by factors that are much more transient than chlorophyll or algal biomass, so in eutrophic lakes pH is hard to predict. In addition, photosynthetic inhibition which occurs on most afternoons obviously cuts down photosynthesis but chlorophyll does not change.

The low part of the pH cycle in surface waters occurs in the dark when algal respiration dominates and acidic CO_2 is produced and photosynthetic uptake of CO_2 ceases. The CO_2 production at night in surface waters is usually greater than that produced by algae alone since zooplankton and small fish migrate from hiding places in the day to forage and respire in the surface waters.

The conclusion is that the cycles of high pH in Lake Merced are due to algal photosynthesis in the day and respiration by algae, zooplankton and fish at night. The remaining problems are:

- Why are the average pH values so high in Lake Merced relative to others that have more, even much more algal biomass?
- Why are the pH values so high in a lake with a relatively acid, sandy drainage basin?
- What is the role of the lakes moderately high alkalinity in setting baseline pH values?

Baseline conditions for alkalinity and pH

As previously discussed, the elevation of pH by photosynthesis during sunny mornings is generated by algal photosynthesis. However, the actual pH value reached takes place on a background of a "natural" or "usual" pH. In general, the background pH is set by the alkalinity or abundance of alkaline minerals in the water. Where there are a lot of alkaline minerals such as in the ocean, the "background" pH (~ 8.1 to 8.2) is higher than most freshwater lakes (~ pH 7; range 6-8) due to the high concentration of salts including those like carbonates that are bases or alkaline salts. However, saline or terminal lakes can have a much higher background, for example the pH of very alkaline and very saline Mono Lake is almost 10.

Considering only freshwater lakes, those on granitic soils have a low pH, sometimes below the neutral point of 7 and are thus in danger from acidification from acid rains. All rain water is slightly acidic (pH ~ 5.4) so all lakes would be acidic if not for the neutralizing effects of the soil and the buffering effects of the basic ions in the lake water itself. The "soft" or low alkaline salt lakes differ from "hard" or moderately alkaline lakes in that there is little carbonate (and some other alkaline salts) to act as a buffer to the introduction of acid in acid rain. Acid rain with pH as low as 4.0 due to sulfates and nitrates from human pollution, can overcome soil neutralization but is not of concern for Lake Merced whose airshed is mostly the open ocean.

If an acid hydrogen ion from the natural carbonic acid in rain meets an alkaline carbonate ion in the soils of the drainage basin, the results is a more neutral water and more neutral pH. When the supply of carbonate is naturally low or runs out, the water becomes acidic. In lakes with carbonate-rich soils such as limestone, there is an abundance of alkalinity so, unlike the case of acid rain, these lakes have high alkalinity and high pH even with considerable amounts of acid rain. Lake Merced has an ample supply of basic ions in the lake but the sandy soils of the San Francisco watershed would be expected to be deficient in basic rocks like limestone. Thus the history of the lake may play a role in its current pH situation.

The equilibrium or average baseline pH in a lake, as distinct from daily or seasonal variations, is set by the amounts and kinds of salts and can be predicted from its alkalinity. Lakes with more alkalinity generally show a higher baseline pH (Saffran & Trew, 1996; Tucker & D'Abramo, 2008). Based on its relatively high alkalinity ($\bar{x}$ = 172 ppm; range 136-230; Kennedy-Jenks, 2010), the equilibrium pH of the Lake Merced water can be predicted empirically from studies in other lake regions as about 8.5 (Fig. 4). The actual daily average pH in Lake Merced in September 2011 was 8.45 with an average daily minimum of 8.2 (mean low) and an average daily maximum of 8.7, thus corroborating the predictions based on alkalinity. The data from September 2011 at SM3 was used since it has the most detailed summer-fall data set gathered using continuously-recording in situ probes. September is a typically a month of high pH values and the frequent blue-green algae nuisance blooms. However, occasional measurements made at various times of years showed that pH over the last 40 years averaged ~ 8.5 (Fig. 2). The alkalinity range of Lake Merced is 136-230 ppm but due to the exponential relationship of pH and alkalinity, equilibrium pH would remain above 8 at all measured alkalinities.

So many changes have occurred to the watershed of Lake Merced that the alkalinity of the original watershed runoff is not known. As mentioned earlier it would be expected to be lower than the present due to the sandy soils. Other sandy watersheds in the US have much lower alkalinities than Lake Merced (e. g. Sand Lake, MI, 55 ppm, Hay, 1994). In contrast to Lake Merced with its alkalinity of 172 ppm, a lake with about 100 ppm alkalinity will have a much lower equilibrium pH just below 8 (Fig. 4). Very soft water such as that from the granite Sierra Nevada will have a low alkalinity. For example, the alkalinity of San Francisco's water supply is less than 10 ppm due to the supply from the granitic Hetch Hetchy reservoir watershed. Some of this low alkaline water was historically used to maintain the elevation of Lake Merced which would have lowered baseline alkalinity and pH.

POSSIBLE SOLUTIONS TO THE HIGH BASELINE ALKALINITY AND PH OF LAKE MERCED

Reduction of eutrophication

Lake Merced is undesirably eutrophic for its current uses. Decreasing eutrophication in Lake Merced is a goal of several strategies including Best Management Practices (BMPs), nutrient removal wetlands, and most in-lake management options. The higher pH excursions in Lake Merced are in part due to algae so fewer algae in the lake would be one possible solution. A substantial reversal in eutrophication with concomitant reduction in chlorophyll would give smaller pH increases. However, with the same alkalinity these smaller pH increases would still occur from a mean pH base of 8.45 so that the standard of 8.5 would still be exceeded. In addition, the pH standard of 8.5 from an average base of 8.2 would require reducing the current chlorophyll concentration by about half.

Large nutrient reductions such as the diversion of sewage inflows to deep thermally stratified lakes can decrease algae (e. g. 75% decrease in phosphate in Lake Washington reduced chlorophyll from 40 to 10 ug/L over a decade, see Horne & Goldman Fig. 22-2, p. 503). However, for shallow lakes, even 50% reductions in TP have modest effects due to internal loading of nutrients from the sediments (e.g. Shagawa Lake, Horne & Goldman, Fig. 22-3, p. 504). Unfortunately, BMPs in most watersheds have a much smaller potential for nutrient reductions. Watershed BMPs have much to offer in terms of reductions of bacteria and sediments but, apart from specially designed wetlands, have so far been less successful in effective nutrient reduction. To my knowledge no BMPs have ever been shown to reduce algae in a large lake. In part this is due to hysteresis effects (Sheffler, 1998) which work against cleanup and include legacy pollution in the sediments. Nutrient reductions in urban areas are further complicated by the increase in airborne nutrients as well as summer runoff from car washing and landscape irrigation. For example the groundwater in the Lake Merced watershed is heavily enriched with nutrients which will take a long time to flush out. Thus watershed BMPs may not achieve the reduction in eutrophication necessary to lower algal productivity, and thus pH, sufficiently to meet Basin Plan standards.

An active lake management technique such as vigorous aeration-mixing is known to reduce nuisance blue-green algae in lakes (for example in the recent project in Cherry Creek, Colorado; Amex 2005) but it is not yet a guaranteed method to decrease overall algal biomass. However, vigorous mixing of top and bottom water would probably reduce larger surface pH increases.

Lake flushing with low alkalinity storm water

Flushing a lake with clean water is an effective solution for many lake problems but is rarely used due to the shortage of the needed volumes of clean water. However, in the case of Lake Merced, there is a source of low alkalinity water; low-alkalinity storm water. If used when appropriate (i. e. when nutrients are low), storm water would dilute salts in the lake and also flush out higher alkalinity water.

The low salinity water flushing solution is ecologically attractive since it restores some of the natural original hydrology. It would require a reconstruction of the dam to allow good outflow of bottom water (or use of a siphon) since the heavier saltier water tends to be in the bottom when low-salinity water flows in over the top in winter.

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FIGURES

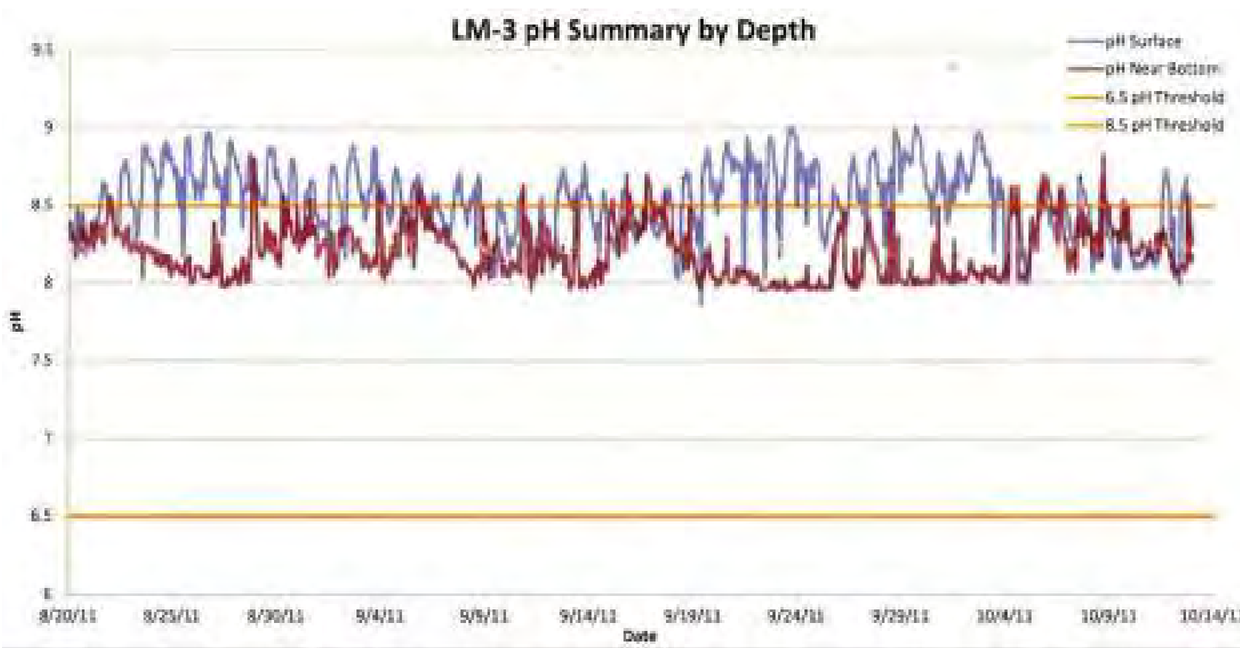

Figure 1. Daily variation in pH in Lake Merced, top and bottom in late summer-fall, 2011. The surface water pH is out of compliance for much of the time, the bottom water occasional so. The pH does not fall below 8 due to the relatively high alkalinity in the lake. Note convergence of top and bottom pH during mixing (Fig. 2) but almost at the pH 8 threshold rather than a lower more acidic value.

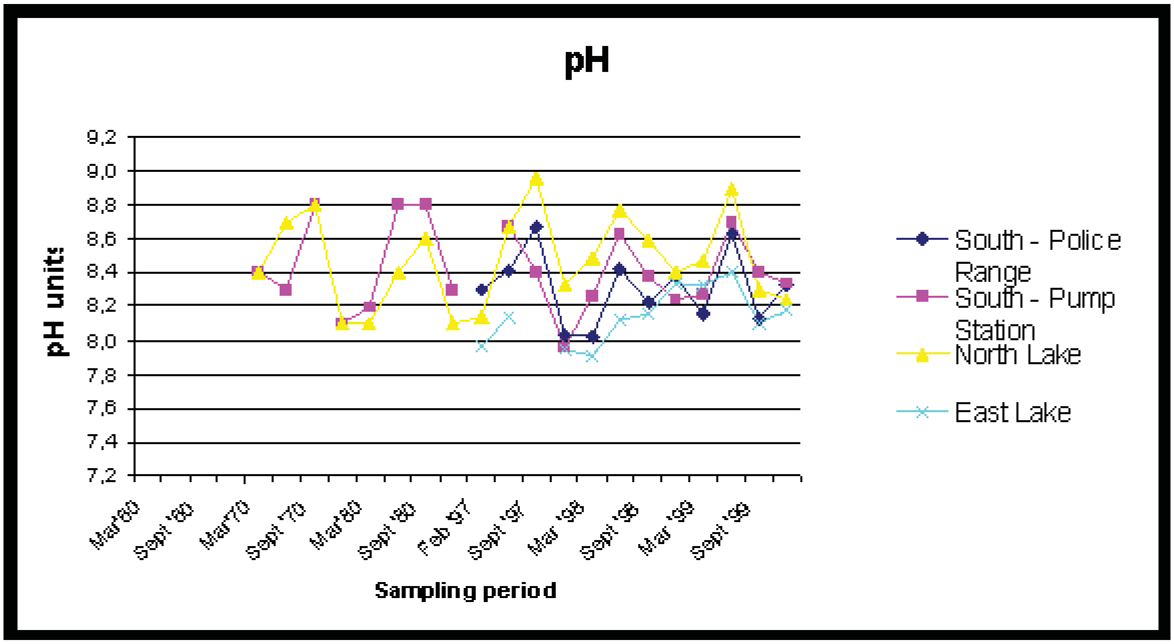

Fig. 2. Long-term pH in Lake Merced 1960-1999. Average pH in the main basin, South Lake, has hovered around 8.5 with the same small range of variation (8-9) as found in the more detailed 2011 data set (from Matuk & Salcedo, 2000).

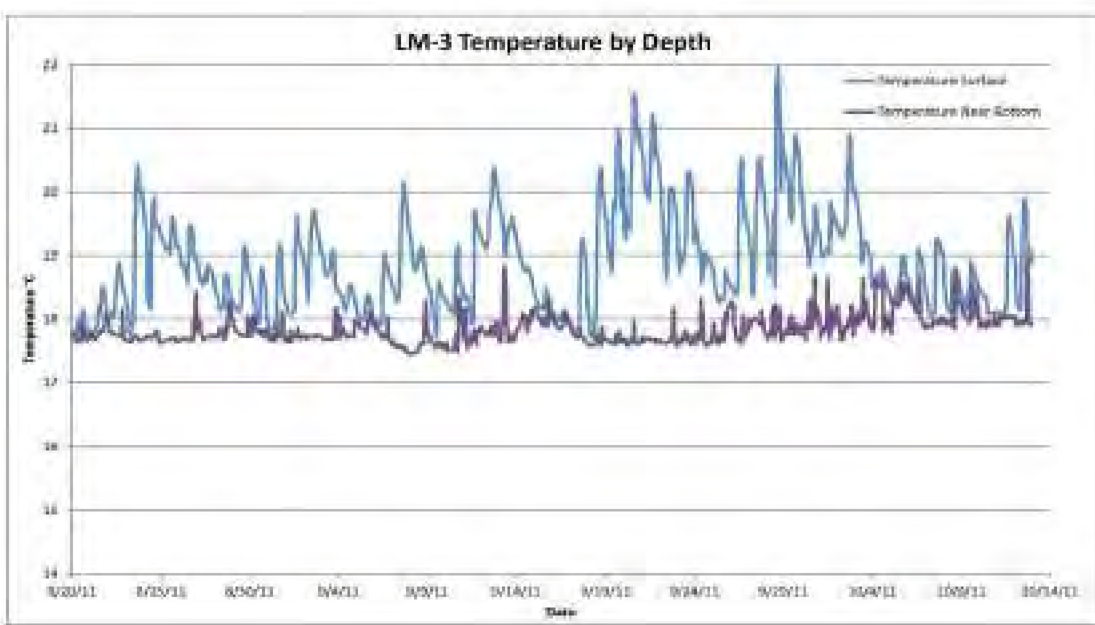

Fig 3. Temperature at surface and near bottom in Lake Merced, late summer-fall 2011 showing a mixing event 16-19 September.

2-23-0862
Exhibit 6
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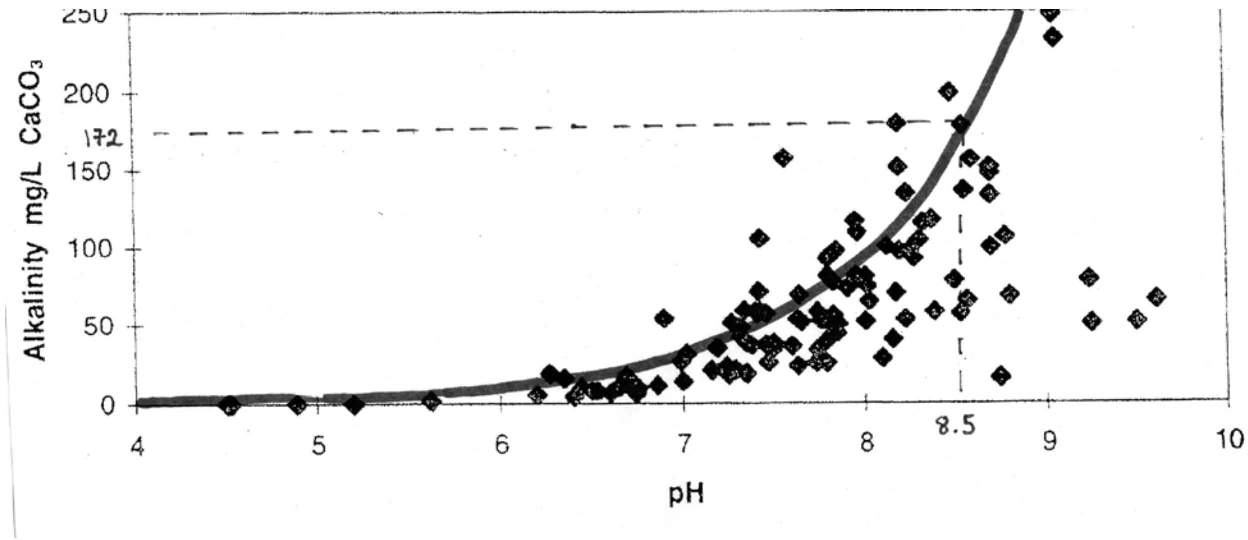

Fig. 4. Relationship of alkalinity and pH in lakes. The average alkalinity of Lake Merced is 172 ppm which corresponds on the figure to a pH of about 8.5. The average pH of the lake in recent years was 8.45. Curve is hand drawn, data from 109 lakes with various morphologies in Alberta, Canada from Saffran & Trew, 1996. Other lakes in different regions show a similar relationship (Wetzel, 2005; Armstrong & Schindler, 1971).

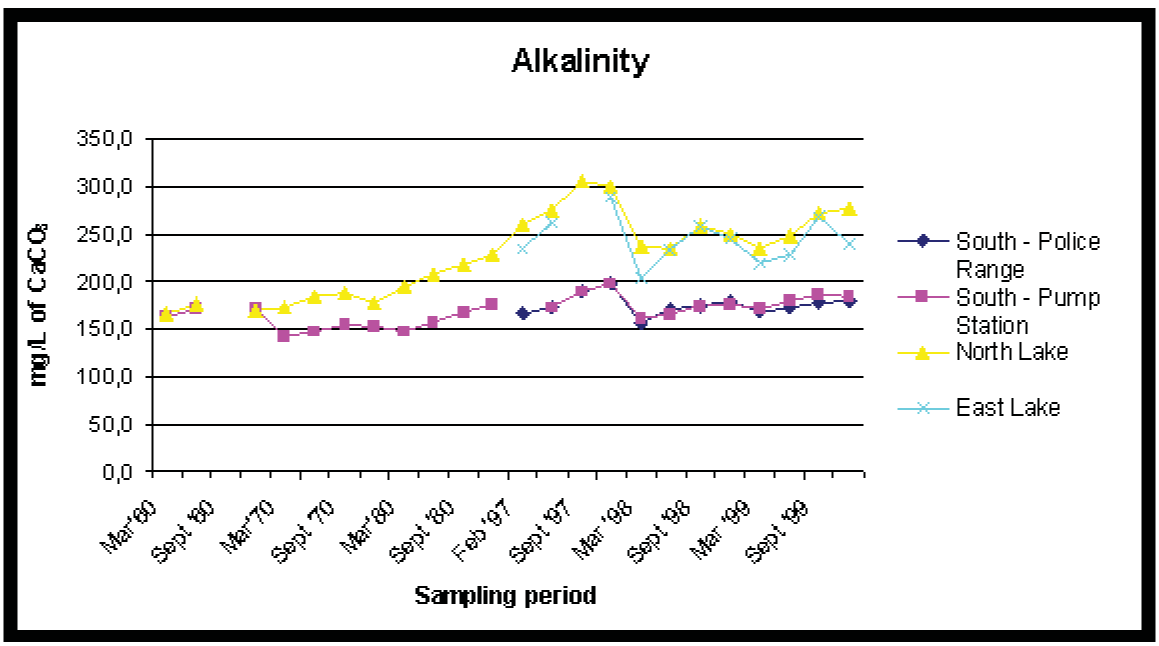

Fig. 5. Long-term alkalinity in Lake Merced 1960-1999. Alkalinity shows an increase from about 150 to 170 ppm in South Lake over time but the smaller more isolated North and East basins show greater increases (from Matuk & Salcedo, 2000).

Memo to: Josh Ferris, Tom Hall
From: Alex Horne
RE: **ESTIMATED NET EFFECTS ON WATER QUALITY WITH INCREASED WATER ADDITIONS TO LAKE MERCED DURING FILLING AND AT STEADY STATE**

DATE**: 9:30 AM 21 AUGUST 2012**

Results: Overview

There are two opposite effects of adding storm and base flow water to Lake Merced. The increase in depth will progressively, but not linearly, decrease algae in the lake by reducing mixing of higher nutrients in deep water up to the surface where they can stimulate algal growth. The opposite effect comes with the nutrients added in the storm water and especially the higher nutrient base flow water. These, if mixing into the lake surface water, will increase algae growth. The balance between the two was estimated using a series of simple models and assumptions combined with a quantitative mass balance approach.

Results: During filling

The net result is that at all rates of filling there will be an increase of 8.1 to 11 ug/L (mean 9.7 ug/l) of chlorophyll *a* in summer in the lake to give mean summer values of 38-41 ug/L compared with the current mean of 30 ug/L. The average of 32% increase in algae is about that which would be analytically detectable from background over a few years. Smaller increases of declines would be obscured by natural seasonal and other variations. The chlorophyll increase would have an effect on the bottom dissolved oxygen (DO) concentrations - probably by making periods of low DO longer than at present. However, the change of about 10 ug/L in chlorophyll would not be noticeable to the public in term of water clarity since all changes fall on the flat section of the Secchi depth-chlorophyll *a* curve where any lake is saturated with chlorophyll above about 15 ug/L. The analogy is that a green lawn that gets a bit thicker grass due to more fertilizer application would not be noticeable to the public. There could be a possible increase visible to the public in edge blooms of blue-green algae which float and thus concentrate at the surface. However, these edge scum are already present in the lake and so the difference would be subtle since the wind direction and speed on the day of observation is the dominant force in the size of the edge scums.

With the installation of the John Muir Wetlands any changes would be small (up or down). The main purpose of the wetland would be to reduce nitrate in the storm water and especially the summer base flow which contains over 100 times the amount of nitrate and ammonia present in the lake in summer. Depending of the details of the design and operation of the wetland, the changes would range from an increase of about 1.5 ug/L chlorophyll (or 31.5 ugL or 5%) in the lake) but for most scenarios there would be either no change from the present a decrease of up to 2.8 ug/L, or 27.2 ug/L (9% decline) in the lake. The kind of plants in the wetland, air temperature, and the actual area of treatment wetland (i. e. excluding berms) would influence the actual drop or slight rise in algae in the lake. Again, this small change would not be noticeable to the public, even if a decrease, and would also be very hard to detect analytically, except over many years of measurement.

1. **FILLING SCENARIO: ESTIMATED NET EFFECTS OF INCREASES IN WATER DEPTH, STORM NUTRIENT INFLOWS (TIN = 610 UG/L) AND YEAR-ROUND BASE NUTRIENT FLOWS (TIN = 3,700 UG/L) TO LAKE MERCED WITH THREE DIFFERENT FILLING SCHEDULES WITH AND WITHOUT THE PROPOSED JOHN MUIR TREATMENT WETLANDS. ALL CHLORPHYLL DIFFERNCES VALUES ARE CHANGED FROM THE CURENT MEAN ANNUAL CONCENTRATION OF 30 µg/L.**

Max WSE (ft)	**Flow diversion threshold (cfs)**	**Average filling time (mo)**	**WINTER Nitrate or TIN (ug/L)**						
			In base flow	**In storm flow**	**Current in lake winter**	**After storms inc base + storm flows**	**Winter increase**	**Depth reduction effect**	**Net winter increase**
No wetland									
7.5	>35	17	3700	610	90	175	85	-24	61
8.5	>35	30	3700	610	90	185	95	-40	55
9.5	>35	42	3700	610	90	182	92	-51	41
Basic wetland									
7.5	>35	17	1	610	90	125	35	-24	11
8.5	>35	30	1	610	90	138	39	-40	-1
9.5	>35	42	1	610	90	136	46	-51	-5
Advanced wetland									
7.5	>35	17	0.5	610	90	116	26	-24	2
8.5	>35	30	0.5	610	90	129	39	-40	-1
9.5	>35	42	0.5	610	90	128	38	-51	-13

Max WSE (ft)	**SUMMER: nitrate or TIN (ug N/L)**				**SUMMER & WINTER (ug N/L)**	**ALGAE (ug Chl/L)**		
	Increase in base flow	**Depth reduction effect**	**Usable over summer baseline**	**Mean usable for 5 blooms**	**Net increase**	**Net effect**	**Conc. in lake**	**Change (%)**
No wetland								
7.5	96	0	96	19	80	11	41	37
8.5	95	0	95	19	74	10.1	40.1	34
9.5	92	0	92	18	59	8.1	38.1	27
Basic wetland								
7.5	25	-24	1	0	11	1.5	31.5	5
8.5	25	-40	-15	-3	-4	-0.5	29.5	-2
9.5	24	-51	-27	-5	-21	-1.4	28.6	-5
Advanced wetland								
7.5	12	-24	-12	-2	8	-0.1	29.9	0
8.5	12	-40	-28	-6	1	-0.9	29.9	-3
9.5	12	-51	-39	-8	-13	-2.8	27.2	-9

Table notes:

- No depth reduction allowance was made for the no-wetlands option in summer since the out-flowing water will be warm and thus not sink to the bottom as will cool wetlands outflow.

Results: At steady state. Without wetlands the steady state would be an increase of about 6 mg/L algal chlorophyll (19% increase). With wetlands, under all conditions, there would be a slight decrease in algae of 1.8 to 3.0 ug/L (6 to 10% decline). Final in-lake concentrations of algal chlorophyll would be 27 to 35.8 ug/L depending on the wetlands choices. It is possible that conditions would further improve over time as internal loading due to dead spring bloom algae are reduced and decrease the BOD loading to the sediments. As with the filling scenario no change in water clarity would be perceptible to the public for many years. It is possible that the public would perceive some decrease in shoreline blue-green algal scums in the late summer and fall. Thus at steady state with wetlands, and improved Lake Merced could be expected with less mean annual algae than at present.

2. **ESTIMATED NET EFFECTS OF INCREASES IN WATER DEPTH, STORM NUTRIENT INFLOWS AND YEAR-ROUND BASE NUTRIENT FLOWS TO LAKE MERCED AT STEADY STATE WITH AND WITHOUT THE PROPOSED JOHN MUIR TREATMENT WETLANDS. WSE = 8.5 FEET (MIDDLE VALUE). ALL CHLORPHYLL DIFFERNCES VALUES ARE CHANGED FROM THE CURENT MEAN ANNUAL CONCENTRATION OF 30 µg/L.**

TIN ug N/L									**Algae (ug Chl/L**	
Winter inflow	Winter increase	Winter depth reduction effect	Winter net increase	Summer net increase	Summer depth reduction effect	Summer usable over bkground	Mean sum over bkground for 5 blooms	All year increase	All year net increase	All year value in lake
No wetland										
158	68	-40	28	74	0	74	15	43	5.9	35.9
Base wetland										
121	31	-40	-9	20	-40	-20	-4	-13	-1.8	28.2
Advanced wetland										
114	24	-40	-16	9	-40	-31	-6	-22	-3.0	27.0

Brief synopsis of method

The winter nutrient loading of both storm water and base flow water was estimated as a cumulative total for the five winter months using flows and TIN (or nitrate-N) concentrations. Algal growth during the winter darkness is low and the entire winter TIN additions (winter base flow and storm flows) can be modeled as a lumped quantitative which is then added to the normal TIN present in the lake over winter. This assumption is based on the widely used correlation between the nutrient concentration in lakes in early spring and the maximum (peak) summer chlorophyll level. Because the Lake Merced work uses an empirically-derived spring-fall mean concentration for comparison, the modeled chlorophyll increase due to the TIN added in storm and winter base flows are also expressed as a mean not a peak.

The summer base flow loading cannot be expressed as a one-shot TIN inflow since inputs of N are continuous. Some of the earlier TIN added will grow algae while the latter additions may come too late for sufficient light to be available. Algae will use the continuously added TIN in a discontinuous fashion resulting in a series of short-term blooms followed by an interval when the next kind of algae will grow and decay in turn. To express the series of short-term peaks due to the continuous TIN addition as a mean value it was assumed that each bloom takes about one month to initiate, peak and decline. Thus in the 7 months of the growth season in Lake Merced, 7 blooms could occur but the first and last blooms will not occur due to the dominance of the growth of the major bloom early in the season and the lack of light for the last bloom in the late fall. Thus only one-fifth of the added TIN will actually increase chlorophyll at any one time. The small summer peaks are not additive but are shown here as an increase in the mean summer value of chlorophyll. There will be some recycling of the nutrients on algal decay but this is accounted for in the empirical relationship determined for Lake Merced between TIN present and resulting algal growth.

The sum of the winter TIN flows (spring-fall peak expressed as a mean increase in chlorophyll over the current value), the spring-fall continuous TIN additions (expressed as an increase in the summer mean due to short-term monthly blooms) gives a single number for algae chlorophyll for each of the 9 variations in flow with and without wetlands for treatment of the inflowing TIN in cold and warm seasons.

The fate of the base flow added in summer is not certain. If passed through the correct design of wetlands, the water would be cool and dense and sink to the bottom of the lake where it would only be used by algae following mixing. This sinking process could be enhanced by designing the channel between the wetland and lake to be shaded by vegetation or a cover. In contrast, summer base flows would be warm and mix with the surface lake water and produce a more immediate eutrophicating effect. Thus the reduction in nutrients and algae due to deeper water can be applied to the wetlands summer base flow but not direct (non-wetlands) inputs.

For this analysis biologically available N (TIN) was taken as the limiting factor since it is in short supply while similarly available P (TP) is relatively abundant. Since inflowing storm water has less TP than the lake, it would have no bio-stimulating effect. So use of the TIN is a conservative method to interpret the effects of nutrients added in storm and base flow water.

Wetlands

The constructed treatment wetlands are assumed to remove nitrate (the main component of TIN summer or winter) with a rate of 500 mg N/m2/d in the 7 month warmer period ($T > 15^oC$) and 100 mg N/m2/d in the 5 month cooler period ($T < 15^oC$). The area needed ranges from 1.3 to 7 acres, approximately within the 5 acre planned area of the John Muir Wetlands. The basic wetland assumes typical cattail-bulrush mixtures. The advanced wetland assumes mostly cattails with only a small bulrush cell at the end to cool the out-flowing water for sinking to the bottom of the lake in summer.

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APPENDIX F

Inventory of Documents Related to Lake Merced and Vista Grande Watershed Water Quality

Contents:

Inventory of Water Quality Reports - Vista Grande Drainage Basin Improvement Project

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Inventory of Water Quality Reports - Lake Merced and Vista Grande

Vista Grande Drainage Basin Improvement Project

Source/Author	Title	Date	Description	Prepared For	Format(s)
Merritt Smith Consulting	Water Quality Investigation and Assessment Report: Potential Water Quality Effects in Lake Merced from Enhanced Ammonia Inputs	October 2001	Evaluates water quality impacts of chloaraminated water discharges (from Hetch Hetchy System) to Lake Merced.	SFPUC	Adobe Acrobat
EDAW, Talavera & Richardson	Lake Merced Initiative to Raise and Maintain Lake Level and Improve Water Quality Task 4 Technical Memorandum: Impacts to Water Quality, Vegetation, Wildlife, and Beneficial Uses	September 2004	Memorandum assesses the physical and biological impacts of raising Lake Merced by 4, 6, and 8 feet above the baseline water surface evelvation of October 2002 (0.5 feet City Datum) and with four optional supplemental water sources.	SFPUC	Adobe Acrobat
URS	Lead Shot Characterization and Risk Assessment Pacific Rod and Gun Club at Lake Merced	September 200	Sampling and assessment of human or ecological hazards from inundation of residual lead shot	SFPUC	Adobe Acrobat
RMC Water and Environment	Vista Grande Watershed Study	August 2006	A planning-level study to identify potential solutions to meet the goal of resolving flooding at the Vista Grande canal and in the Vista Grande drainage basin for the 10-year storm event.	Daly City, CCSF	Adobe Acrobat
URS	Surface Water Characterization and Screening Risk Assessment Pacific Rod and Gun Club at Lake Merced	September 200	Testing of lead concentrations in surface waters after lake levels had risen to over 7 feet City Datum. Some lead levels were found to be above drinking water standard.	SFPUC	Adobe Acrobat

Inventory of Water Quality Reports - Lake Merced and Vista Grande

Vista Grande Drainage Basin Improvement Project

Source/Author	Title	Date	Description	Prepared For	Format(s)
RMC Water and Environment	John Muir Wetalnd Conceptual Design Update	September 200	Conceptual design of a treatment wetland between John Muir Drive and the Vista Grande Canal. Includes pollutant removal estimates.	SFPUC	Adobe Acrobat (scanned)
Jacobs Associates	Vista Grande Drainage Basin Alternatives Report: Vol 1 Alternatives Evaluation Report; Vol 2. Supplemental Analysis; Vol 3. Lake Merced Alternative; Vol 4. Permitting Workbook	2007-2011	Evaluation of alternatives for the Vista Grande Drainage Basin Improvement Project	Daly City	Adobe Acrobat
Stillwater Sciences	Revised Pollutant Attenuation Rate Estimates for the Proposed John Muir Wetland	December 2008	Provides updated estimates of expected pollutant removals for the proposed 8.2 acre (3.3-ha) John Muir Wetland that is being evaluated for design and implementation by the	SFPUC	Adobe Acrobat
Kennedy/Jenks Consultants	San Francisco Water System Improvement Program (WSIP) Lake Merced Water Levels Restoration (CUW30101) Draft 100% Conceptual Engineering Report	January 2009	The report was developed for SFPUC to provide conceptual engineering to increase and maintain Lake Merced water levels.	SFPUC	Adobe Acrobat

Inventory of Water Quality Reports - Lake Merced and Vista Grande

Vista Grande Drainage Basin Improvement Project

Source/Author	Title	Date	Description	Prepared For	Format(s)
Kennedy/Jenks Consultants	Lake Merced Water Quality Data Organization, Review, and Analysis	January 2010	Report reviews the water quality data gathered from 1997 to 2009; to determine if the 'health' of Lake Merced has improved, remained constant, or has degraded; and determine if the current water quality monitoring program is accurately capturing the water quality of Lake Merced and provide recommendations accordingly.	SFPUC	Adobe Acrobat
SFPUC	Lake Merced Watershed Report	January 2010	Planning document, provides a vision and management stategies. Provides background information on Lake and watershed.	CCSF	Adobe Acrobat
SFPUC	2009 Annual Lake Merced Water Quality Monitoring Report	November 201	Summary of the 2009 Lake Merced water quality data, comparison to KJ 2010 summary evaluation of 97-08 data, finds water quality has remained relatively constant.	SFPUC	Adobe Acrobat
EOA, Inc.	Lake Merced Stormwater Enhancement Project Preliminary Water Quality Screening Results 2003/04 - 2008/09 Wet Weather Seasons	June 2011	Project to assess the feasibility of diverting stormwater runoff from the VG drainage basin to South Lake Merced. Bacteria, metals and nutrients monitoring data collected. Bacterial indicator data was collected 24 to 72 hours after diversions	North San Mateo County Sanitation District (Daly City)	Adobe Acrobat

Inventory of Water Quality Reports - Lake Merced and Vista Grande

Vista Grande Drainage Basin Improvement Project

Source/Author	Title	Date	Description	Prepared For	Format(s)
CH2M HILL, Duffy Co.	Vista Grande Diversion Feasibility Study	October 2011	Evaluation of alternatives to divert Vista Grande water to Lake Merced. Includes summary of water quality data and assessment of potential water quality impacts.	CCSF, Daly City, San Mateo County	

Inventory of Water Quality Data - Lake Merced and Vista Grande

Vista Grande Drainage Basin Improvement Project

Title	Source/ Author	Date	Description	Document Type	Format(s)
Lake Merced Data - Comprehensive	SFPUC	1997-2009	Water quality tables and charts for a series of locations on Lake Merced. Data collected at different times for different constituents	Spreadsheet	MS Excel
Pilot Stormwater Treatment Project Data (Vista Grande Canal) *Lake Merced TM No. 3 Vista Grande Canal Lake Merced Pilot Stormwater Treatment Plant Project (CH2Mhill, January 2004)*	CH2MHill	2004	Data for Vista Grande Canal and Lake Merced (organic and inorganic chemistry with heavy metals).	Spreadsheet	MS Excel
Lake Merced Figure	Unknown	7/24/2006	GIS layers of Lake Merced	Compressed Zip Folder	HTML, APM, SSF, APL, DBF, PRJ, SBN, SBX, SHX, SBF, SHP
Vista Grande Canal Data - 2008	SFPUC	2008	Vista Grand Canal data - inorganic/organic chemistry data 12/6/07 to 10/2/08.	Spreadsheet	MS Excel
Vista Grande Canal Sampling Results with Metals Summary (2007-2008)	SFPUC	11/6/2008	Vista Grande Canal data- E.coli, nutrients, metals, temperature)	Spreadsheet	MS Excel
John Muir Wetland (Pathogen & nutrient summary)	SFPUC	11/25/2008	Data for summer and winter for nutrients, metal, and coliform with flow.	Spreadsheet	MS Excel
Lake Merced Temperature Data (2004-2007)	SFPUC	11/27/2008	A 3-sheeted spreadsheet that includes temperature data for several Lake Merced locations from 5/27/04 to 12/27/07.	Spreadsheet	MS Excel

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APPENDIX G

Basic and Advanced Treatment Wetland Design Concepts and Water Quality

Contents:

Summary of concepts and considerations for basic and advanced constructed treatment wetland

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Basic Wetland (resembles natural wetlands)

- One or more ponds with reeds around
- Random assortment of unplanted vegetation ("self-design")
- *Advantage* – simple
  Disadvantage - hydraulic short-circuiting & low carbon flux for microbes that do much of the pollution removal

Kadlak's textbook

Georgia example

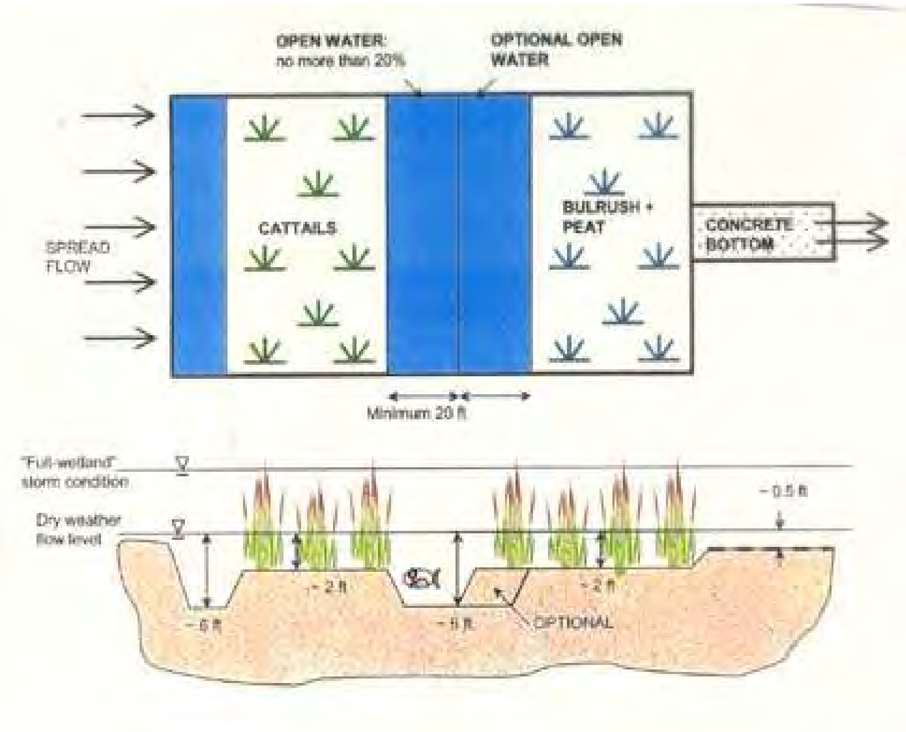
Hayward DUST marsh

Prado, OC, CA

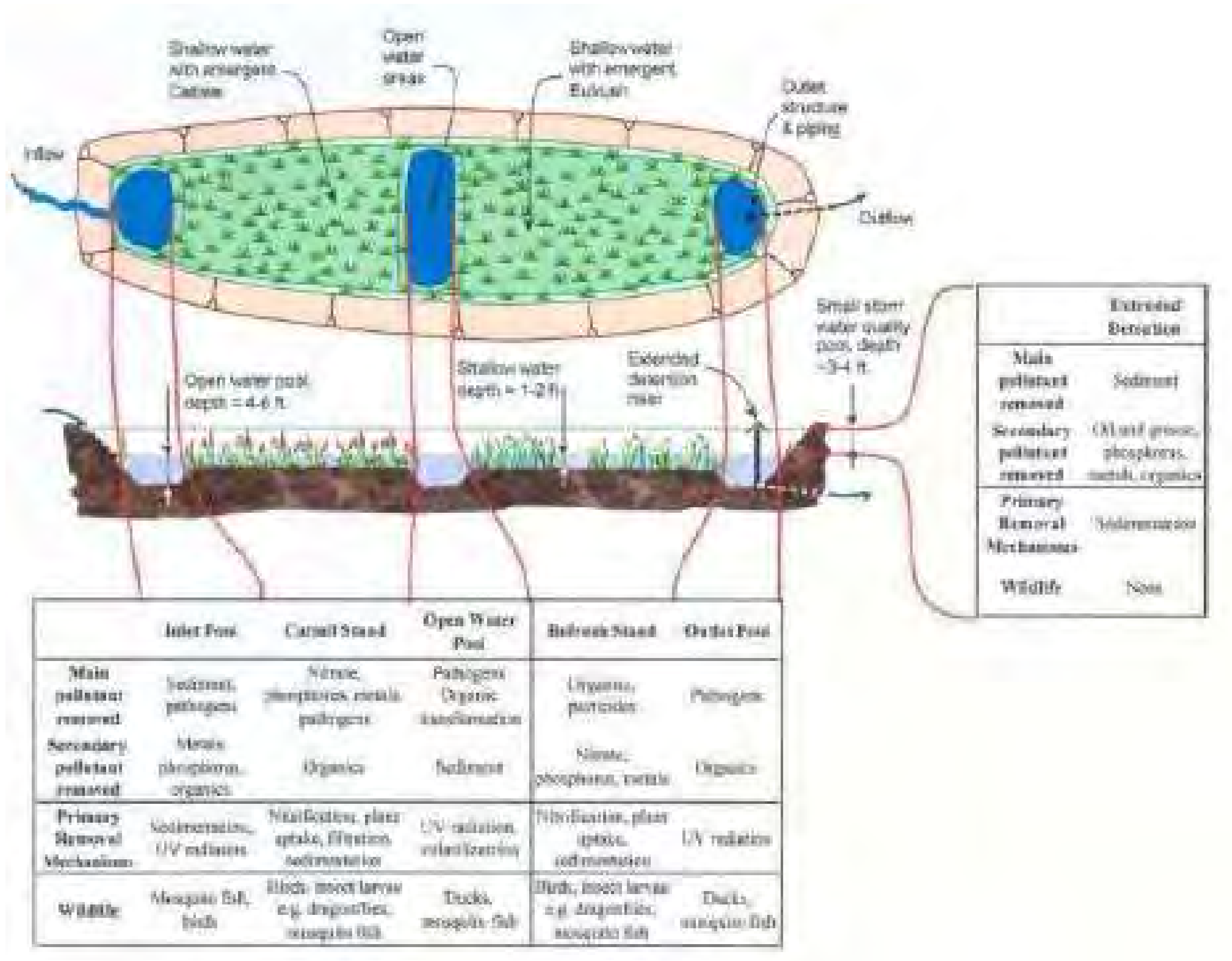
IRWD, Irvine CA

Advanced wetlands (Unit Process design)

- 4-5 cells each with a specific pollution task
- Specific kinds of vegetation planted ("engineered-design")
- *Advantages*- No hydraulic short-circuiting & more carbon for microbes that do much of the pollution removal
- *Disadvantages* – more design, planting needed, but construction similar



Advanced wetlands: design & functions



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MEMORANDUM

FROM: Lauren Garske-Garcia, PhD – Senior Ecologist

TO: Oceane Ringuette – North Central Coast District Supervisor
Stephanie Rexing – North Central Coast District Manager
Dan Carl – North Central Coast Deputy Director

SUBJECT: Mitigation Framework for the *Vista Grande Drainage Improvements Project* (CDP Application 2-23-0862)

DATE: May 28, 2024

The purpose of this technical memorandum is to describe a staff recommended mitigation framework for the *Vista Grande Drainage Improvements Project* (Project) proposed by the City of Daly City (City) in CDP Application 2-23-0862. This recommendation is first framed by the context of the Project, after which the basis for the Commission's typical mitigation requirements and a framework that has evolved over recent years are described. **New in this case, is an approach to account for mitigation compensating for habitat impacts that would be implemented ahead of impact observation.** This approach would adapt and expand the Commission's framework to enable advance and early mitigation (AEM) opportunities consistent with the logic applied in other recent decisions. Examples are provided to help illustrate how the AEM framework would be used for various scenarios at the Project. Finally, the mitigation framework recommended for the Project, including the new AEM components, is illustrated to provide a comprehensive overview of the holistic mitigation approach. This is simultaneously aimed at providing the City with flexibility for mitigation planning purposes and the Commission with assurance of necessary ecological compensation for the adverse impacts to sensitive coastal resources that would occur as part of Project authorization.

Vista Grande Drainage Improvements Project

In the proposed Project, the City would construct various infrastructure improvements across multiple features and locations associated with the conveyance of stormwater to an ocean outfall at Fort Funston. Among these is a diversion structure that would enable the City to redirect some of these storm flows from the Vista Grande Canal into the City of San Francisco's Lake Merced system (a series of four connected lake features), thereby supporting their shared municipal goals of managing stormwater, increasing lake capacity, and ultimately, contributing to improved lake water quality. Following the Project's construction phase, water levels at Lake Merced would be operationally increased and managed through the diversion of stormwater to the lake. The analysis submitted with the City's application package assumed a base lake level of 6.0 feet water surface elevation (WSE), though this is recognized to vary seasonally and across years, depending on environmental conditions (*e.g.*, drought).[1] The Project's intent is to achieve and sustain an operational lake level of approximately 8.5 feet WSE, with allowance for up to 9.0 feet WSE during abbreviated periods

[1] In the period between January 2019 and May 2024, daily data indicates that water levels at Lake Merced have fluctuated, on average, around 1.5 feet annually. On a seasonal basis, water level variance has ranged from 0.8 to 3.0 feet in a given year. Water level dynamics are driven by a combination of precipitation, groundwater, evaporation, and transpiration.

to accommodate particularly large storm events. Relative to the base level used in the City's analysis, the 8.5-foot WSE target represents a 2.5-foot increase in water coverage throughout the system, and the inundation of an estimated 15 acres of existing habitat, mostly composed of wetlands and ESHA.[2,3] The City's team anticipates that once managed operational increases of the lake level commence, it will require three to four years to reach the target 8.5 feet WSE though this will be influenced by annual climate patterns. Increasing lake levels by several feet, even gradually, will consequently drown surrounding ecosystems and lead to the conversions of some vegetation communities, as has been preliminarily estimated by the City. Commission staff additionally anticipate that there will be indirect impacts on lakeside vegetation located above the projected waterline, as the water table would be influenced by the lake volume but vary with both underlying geological conditions and the physiological responses of plant species present. As these indirect impacts will reflect an ecological response complicated by many factors, they are not possible to predict with the models available and would instead be required to be monitored, measured, and fully mitigated for by a set point in the future.

Staff estimates for construction and direct operational impacts, including both temporary and permanent impacts across a multitude of habitat types, total approximately 20 acres. Applying the Commission's typical mitigation approach to this, staff estimates the City would need to provide around 57 acres of compensatory mitigation for the Project. A significant portion of this is associated with non-lake construction and would be addressed in ecosystems elsewhere, as appropriate (*e.g.*, Fort Funston dunes); however, approximately 2.5 acres of impacts are estimated for lake-associated construction and 10.5 acres for the subsequent lake level increases, and approximately 38 acres would be necessary for this subset of affected resources. While mitigation expectations for construction impacts are well-established by Commission practice, consideration for operational impacts is less so.[4] In this case, there would be a significant lag between the commencement of construction and the commencement of operations due to the time required to complete infrastructure construction. During a meeting on April 24, 2024, the City anticipated a timeline in which, following a June 2024 Commission hearing and approval, the project would go out for bid that fall, construction would begin in October 2025 and be completed in Spring 2028, operational diversions of stormwater to Lake Merced would begin later that same year with the start of the wet season, and the target water level of 8.5 feet WSE would likely be achieved in 2031 or 2032. This suggests that **there may be approximately four years between the time of permit authorization and the commencement of operational impacts**, which is the point in time staff recommends recognizing the impacts due to deliberately altered lake levels under the City's operational management.[5] It is feasible that this lag may still expand or contract as a result of adjustments to construction schedules, drought conditions, or other unforeseen circumstances. Nonetheless, **there is a relatively unusual opportunity here for the provision of compensatory mitigation by the City *ahead* of the adverse ecological impacts** that would be sustained as a result of Project authorization.

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[2] As of May 16, 2024, the daily water level at Lake Merced was measured as 7.36 feet WSE.

[3] Available habitat mapping for Lake Merced is based on a 2011 effort, which is considered outdated and had been completed using a coarser set of vegetation community mapping standards than typically required (*i.e.* vegetation communities were not characterized using the Manual of California Vegetation alliances and associations). Although the City was encouraged to submit updated materials, it has instead opted to wait until pre-construction to complete revised mapping – this endeavor is reinforced through a requirement within the recommended permit conditions. The updated mapping would be used as a baseline from which adverse impacts are calculated following subsequent mapping events to evaluate the degree of change among wetlands, sensitive natural communities, and other ESHA at the site.

[4] Typically, the Commission anticipates compensatory mitigation would be implemented concurrently or shortly after the commencement of impacts and completed, having met all required success criteria, within a set amount of time. The minimum performance period is often 5 years following mitigation implementation, though depending on the resource, may necessarily be longer.

[5] For the purposes of managing expectations and tracking among all parties, this would occur regardless of the rate of water level increase thereafter and would rely on pre-construction baseline mapping in conjunction with two post-operational commencement mapping events to evaluate change in wetland and sensitive habitat representation at Lake Merced.

Past Mitigation Approaches and Existing Framework

The Commission's typical mitigation ratios necessarily reflect compensation exceeding a 1:1 ratio because of the temporal losses to ecosystem functions and values as well as the significant uncertainty associated with created or restored habitat in delivering such functions and values equivalent to established natural systems. Temporal losses inevitably result from the delays between ecological impacts, the time of mitigation implementation, and that required for subsequent maturation of the mitigated area to a condition that would replace lost resource functions and values. Ecosystems simply require time to develop their complex structures, interactions, and processes. In some cases, they may never fully achieve a comparable state as to what they are meant to replace. Uncertainties in long-term mitigation performance are largely an artifact of limited monitoring requirements and durations, with the Commission (and other entities, broadly) necessarily making assumptions about the long-term functions and values that would be provided based on apparent trajectories at the end of a specified point in time. That point may be based on some number of years having elapsed and/or the achievement of specified success criteria, after which the general interpretation is that an ecosystem should be demonstrably on its way towards a self-sustaining condition with limited (if any) ongoing management interventions. Thus, by imposing ratios based on impacted habitat acreage such that the mitigation acreage required exceeds that impacted, the underlying assumption is that the provision of ecological functions and values at a lower level than where impacted but distributed across a greater area will eventually result in equivalency. The spatial multiplier used (and expressed as a ratio) is intended to ensure an acceleration in that recovery of ecological functions and values and reflect both the uncertainties and known challenges in developing equivalent ecological conditions through compensating strategies. The ratios also carry assumptions about mitigation performance timing.

In recent years, the Commission has been refining its approach to compensatory mitigation and a framework has evolved where ratio adjustments have been more consistently structured to reflect not only its typical use of 3:1 and 4:1 ratios for ESHA and wetlands, respectively, but also to recognize differences in the mitigation strategies applied, their relative values, and to provide flexibility to applicants, particularly those with larger, complex projects where mitigation planning can be especially challenging.[6,7,8] Other refinements that have been applied include provisions for significantly

[6] The use of 3:1 and 4:1 base ratios for ESHA and wetlands, respectively, is generally intended to be applied to permanent impacts. Permanent impacts are interpreted as where areas or key ecological functions would be lost to development, frequently disturbed in order to maintain development, involve significant ground disturbance, or necessitate more than 12 months for recovery following the conclusion of disturbance. By contrast, temporary impacts are interpreted as those that would not significantly disturb the ground and resources are able to recover to conditions comparable to that pre-development by the end of a designated period. Where temporary impacts are brief in duration and recover within 12 months of the initial point of disturbance, a 1:1 mitigation ratio is usually applied. As appropriate, long-term temporary impacts may be applicable in some cases and are interpreted as where impacts may be intermittent or sustained for up to a 24-month period during development construction such that resource recovery may require more than 12 months following the initial point of disturbance but no more than 12 months following the conclusion of disturbance. When long-term temporary impacts are recognized, the mitigation ratio is generally adjusted to 50% of the base ratio, such as 1.5:1 for ESHA and 2:1 for wetlands, respectively.

[7] When the Commission requires a particular ratio for mitigation, the assumption is most often that the mitigation will be provided as either in-kind habitat creation or the substantial restoration of existing habitat. At times, other mitigation strategies may be specified, namely habitat enhancement or preservation although these two strategies provide relatively less ecological benefit beyond the existing condition. In the case of habitat enhancement, the Commission has recognized efforts that would restore one or two functions to a degraded ecosystem (as opposed to a full suite of functions that would be restored under substantial restoration). With preservation, no active improvements are made to habitat, and it is simply removed from the threat of future development. Consequently, the Commission has come to often require greater ratios if and when these less involved strategies are employed, typically double and triple the applicable base ratios that would otherwise be applied. For example, impacts to ESHA that require mitigation at 3:1 might alternatively be provided as habitat enhancement at 6:1 or as habitat preservation at 9:1. Another situation that occasionally arises is the need to consider out-of-kind mitigation where in-kind may not be an available option. Although the Commission must still be able to find that there is a well-supported nexus between the impacted habitat and any accepted out-of-kind habitat, out-of-kind mitigation often provides relatively less direct value to the resource impacted than would an in-kind option. Thus, in instances where out-of-kind mitigation is contemplated, ratios are usually doubled relative to the base expectation (i.e. out-of-kind mitigation for ESHA, to be provided as habitat restoration or substantial restoration would go from 3:1 to 6:1, and if provided as enhancement, would multiply again for that adjustment to 12:1, etc.).

[8] For example, see California Department of Transportation (Caltrans) CDP 2-20-0282 for Gleason Beach Highway 1 Realignment, California

delayed mitigation implementation. For example, where mitigation would follow a 5-year minimum performance period and typically be expected to be implemented within 5 years of impacts, an escalator of up to 0.5:1 per year has been required if mitigation implementation is delayed beyond that window, and if mitigation were not completed or underway for at least 3 years and meeting interim performance criteria within 10 years of project impacts, requirements for a supplemental mitigation plan that would offset the prolonged impacts and potentially necessitate a return to the Commission for reconsideration.[9] **Figure 1** summarizes the existing cumulative architecture of compensatory mitigation ratio schedules with an ESHA example, though each permitted project has been addressed individually according to its circumstances and the evolution of the Commission's practice at the time. What is notable about this framework, including Figure 1 as well as the elaborations provided in footnotes on the preceding page, is how it can be readily adapted to work with different base ratios depending on the subject resource(s) (including both ESHA and wetlands) or other considerations (*e.g.*, temporary vs. permanent impacts), different mitigation strategies (*i.e.* habitat creation, substantial restoration, enhancement, and preservation), and different mitigation monitoring requirements (*e.g.*, a typical 5-year requirement vs. longer for slower-developing resources, or where mitigation may be tied to the life of a permit). It importantly provides the Commission with a mechanism to assure fair compensation will be required when mitigation details are still under development at the time of a project's hearing.[10] It also provides Permittees with transparency, consistency, and flexibility for their mitigation planning.

Simultaneously, there has been a general trend among regulatory agencies to contemplate opportunities for advance mitigation, whether this be provided through mitigation banks or by individual entities anticipating future mitigation requirements. For example, the Commission has been involved in the development and authorization of mitigation banks in recent years, enabling the purchase of credits as a potential compensation option for coastal habitat impacts into the future.[11] At the staff level, the Commission has also been involved in contributing to Regional Advance Mitigations Needs Assessments (RAMNAs) developed by partners at Caltrans and Regional Conservation Investment Strategies (RCISs) developed as part of a program based at CDFW. The Commission's use of advance mitigation options in permitting has been limited in the past and moreover, framed in contexts unique to each project. These have acknowledged the benefit of mitigation implemented ahead of the impacts meant to be compensated for but have not necessarily applied a broader lens in light of the Commission's evolving mitigation practice.[12] The Project at Vista Grande (and more specifically, the portion at Lake Merced) provides an opportunity to meaningfully adapt the Commission's evolving mitigation framework to incorporate early and advance mitigation and afford the City the benefit of AEM implementation.

Framework Expansion for Advance and Early Mitigation

Based on the existing framework architecture described above, the endeavor here is to offer an expansion that incentivizes and enables AEM in the context of the proposed Project while maintaining respect for the Commission's

American Water Company A-3-MRA-19-0034 and CDP 9-20-0603 for Monterey Peninsula Water Supply Project, Federal Highway Administration (FHWA) CD-0001-21 for North Coast Monterey Bay Sanctuary Scenic Trail, and California Department of Transportation (Caltrans) CDP 2-23-0300 for Marin County Highway 1 CAPM.

[9] For example, see California Department of Transportation (Caltrans) CDP 2-23-0300 for Marin County Highway 1 CAPM.

[10] Although project applicants are still necessarily required to demonstrate that sufficient mitigation opportunities are available by the time of permit hearing and to show that progress is being made in good faith to secure options deemed viable by Commission staff and ultimately, the Commission.

[11] For approved mitigation banks, see Beach Oil Minerals (BOM) and Los Cerritos Wetland Authority (LCWA) CDP 9-18-0395 for Upper Los Cerritos Wetlands Mitigation Bank, and City of Long Beach CDP 5-09-071-A3 for Colorado Lagoon Mitigation Bank.

[12] For example, see California Department of Transportation (Caltrans) CDP 6-15-2092 and NCC-NOID-0005-15, California Department of Transportation (Caltrans) NCC-NOID-0001-22 for Carmel Valley Bike Trail Connection, City of San Diego CDP 6-22-0196 for El Camino Real Bridge/Road Widening, and California Department of Parks and Recreation, and North Coast Redwoods District CDP 1-22-0358 for Stagecoach Hill Azalea Reserve.

typical mitigation practices. Here, **'advance mitigation' refers to the fulfillment of mitigation obligations ahead of any project impacts whereas 'early mitigation' refers to when mitigation has been implemented ahead of any project impacts but has not yet achieved final performance criteria though it assumes it is on-track.** Applicable ratios are based on the time of final performance achievement rather than the time of implementation for a given area. Ratio adjustments for AEM need to be rooted in the expected reduction of ecological losses over time, and uncertainties associated with sustainable performance into the long-term as well as those regarding the provision of equivalent functions and values relative to undisturbed natural ecosystems. Annually-adjusted ratio discounts are provided at rates corresponding to the generally expected rates of ecological function and value development, these being greater initially and attenuating as a system matures. Whereas a typical mitigation approach relies primarily on compensation through spatial adjustments, the operative mechanism for AEM is time.

The recommended AEM ratio schedules are anchored by the Commission's typical ratios and assumptions while providing a 50% discount for mitigation delivered the year ahead of impacts, and a full discount (resulting in a 1:1 mitigation ratio) when provided by as many years ahead of the impact as would be required for performance evaluation. In other words, if a 5-year monitoring period were required, mitigation would need to be completed and fully performing more than 5 years prior to impacts to be credited at 1:1. This extended tail in reaching 1:1 is recommended because the Commission's typical performance period is not intended to reflect 100% equivalency between pre-project and mitigated conditions at the end of the designated monitoring/performance period. Rather, it instead demonstrates that mitigation is performing on-track to develop more fully with time. At the end of a typical monitoring/performance period (*i.e.* not AEM), the assumption is that the mitigated system is largely self-sustaining and concerned parties can be reasonably confident in its long-term viability so intensive monitoring is no longer necessary; however, the risk of yielding insufficient compensation because the mitigated system is likely to underperform relative to a natural one remains but this is effectively guarded against through the ratios reflecting spatial increases and a total acreage that is intended to provide equivalent functions and values.[13] Though AEM relies heavily on temporal mechanisms to address risk, this likelihood of having provided equivalent ecological value by the conclusion of a monitoring term is low and so, some part of the spatial element is maintained at a ratio greater than 1:1 to address the gap until it dissipates over time to reflect additional ecosystem maturity.

In the context of the subject Project, the following examples illustrate how the AEM expansion as provided in Staff's recommended conditions would be applied to habitat mitigation requirements, but these are not intended to represent an exhaustive set of scenarios. Rather, they are meant to aid in the interpretation of how different situations could be accommodated within the framework. The matrices in **Figures 2 and 3** (for ESHA and wetlands, respectively) assume an approval at the Commission's June 2024 hearing and commencement of mitigation implementation in Fall 2024, with operational stormwater diversions and lake level management commencing in Fall 2028. As outlined in red in the matrices, the schedule would enable ratio reductions to 2:1 for ESHA and 2.67:1 for wetlands. To receive these ratios, mitigation would need to be performing and meet all final success criteria by Fall 2029. Another conceivable scenario would be where mitigation implementation is postponed until Fall 2025 but diversions still begin in Fall 2028 (*i.e.* the temporal lag between impacts and performing mitigation increases by a year) – in this case, the AEM schedule would be reflected by a rightward shift across the matrix, to 2.25:1 for ESHA and 3:1 for wetlands. By contrast, an alternative scenario where the mitigation implementation schedule is maintained but the diversion schedule is delayed by a year, representing a reduced temporal lag between impacts and mitigation delivery by a year, would be reflected as a

[13] In some cases, it may be appropriate to continue to monitor in some limited way until a designated point in time. For example, in situations where mitigation is tied to the life of a permit or specific activity, such as the extraction of seawater for use in an aquaculture facility as was recently seen in the Commission's April 2024 decision for the Humboldt Bay Harbor, Recreation & Conservation District seawater intake project (CDP 1-21-0653). In such examples, the intent is to generally verify continued performance over the long-term to ensure the impacts of ongoing activities are fully mitigated for.

leftward shift across the matrix, to 1.75:1 for ESHA and 2.33:1 for wetlands. If both mitigation implementation and water diversions were delayed by a year, to 2025 and 2027, respectively, the feasible ratio reductions would be 2:1 for ESHA and 2.67:1 for wetlands assuming mitigation met final criteria by Fall 2030.

In **Figure 4**, the example adjusts the ESHA mitigation schedule for a longer minimum performance period of 10 years, which may be applicable in some ecosystems such as those where tree layers must develop. In this case, the discount is reduced per annual time step to reflect the more gradual mitigation trajectory but relies on the same anchor points at the year of anticipated performance under a non-AEM situation and a 50% discount by the year before impact(s). Finally, in **Figure 5**, a different adjustment is shown for the use of an enhancement mitigation strategy as opposed to the habitat creation or substantial restoration strategies typically assumed by the Commission's ratios – this would be doubled to anchor at 6:1 and 3:1. In this case, the proportionality of the discount with the ratio is maintained by doubling the discount per time step.

A Comprehensive Approach

With this Project, there will be both construction and operational impacts to sensitive habitats. These are discussed extensively within the staff report and provided for in the mitigation requirements articulated in Staff's recommendation. These requirements would employ both the general mitigation framework as it presently exists and the expansion accounting for AEM opportunities, and as described in this memo. Comprehensively, these can be merged to provide a single conceptual architecture for the compensatory mitigation approach as shown in **Figure 6**, and adapted to the Project-specific schedule even as it may potentially adjust following approval. The framework also works readily with the current uncertainties about specific impact acreages, including those estimates that will be validated via updated vegetation mapping as well as those that are presently unknowable in full but will be necessarily determined through monitoring. The inherent modular nature of the mitigation framework additionally lends itself to mitigation phasing, should some portions of the mitigation be implementable sooner than others or require additional time to achieve performance success. **By providing both clarity and flexibility to the Commission and the Project proponents, the framework establishes a shared understanding of expectations simultaneously respectful of the Commission's precedent and technical basis for mitigation requirements, and opportunity for incentivizing meaningful ecological outcomes while reducing mitigation obligations and associated expenses through AEM.** It is with this lens and understanding that the City has viable mitigation opportunities available to them that I recommend the Commission employ the framework for the Project as described herein.

Figure 1 5-year ESHA Mitigation Delivery (Creation/Substantial Restoration)	implementation on typical schedule following impacts[0]						implementation delayed >5y following project impacts[1]					implementation delayed >10 years following impacts, or incomplete delivery w/ <3y meeting interim performance[2]				
	TYPICAL						DELAYED					SIGNIFICANTLY DELAYED				
delayed implementation (+>5y)												TBD by ED or CCC, as determined				
delayed implementation (+5y)											5.5:1					TBD
delayed implementation (+4y)										4.5:1					TBD	
delayed implementation (+3y)									4.5:1					TBD		
delayed implementation (+2y)								4:1								
delayed implementation (+1y)							3.5:1									
typical 5y schedule						3:1										
delayed performance (+1y)							3:1									
delayed performance (+2y)								3:1								
delayed performance (+3y)									3:1							
delayed performance (+4y)										3:1						
delayed performance (+1y)											3:1					
	0	**+1**	**+2**	**+3**	**+4**	**+5**	**+6**	**+7**	**+8**	**+9**	**+10**	**+11**	**+12**	**+13**	**+14**	**+15**

	initial year(s) of implementation within 5y of impacts, no performance evaluation at first point regardless of year
[unsaturated colors]	implementation underway, interim performance evaluations
[saturated blue]	final year of implementation, assumes full performance achieved
[saturated orange]	increased ratio imposed given >5y delay in mitigation implementation
[saturated purple]	action TBD as determined by ED or Commission, given >10y delay in mitigation implementation or incomplete delivery w/ <3y performance and meeting interim criteria

[0] assumes a typical mitigation project's requirement of 5 years of monitoring ahead of final performance evaluation; implementation is expected to occur within 5 years of impacts but final performance may occur as late as 10 years due to implementation delays and/or extended performance periods necessitated by underperformance relative to final success criteria

[1] mitigation implemented more than 5y after project impacts commence would be considered delayed beyond what the original mitigation ratio accounted for and thus, imposes an annual increase of 0.5 acres per year

[2] mitigation that has not been implemented by 10y after project impacts commence, or has not been delivered with at least 3y meeting interim performance criteria, is considered significantly delayed and warrants reassessment by the Commission's Executive Director and upon their evaluation of the situation, potentially a return to the Commission for reconsideration

Figure 2 5-year ESHA Mitigation Delivery (Creation/Substantial Restoration)	completion ahead of impacts, more complex functions significantly developed[2]	completion ahead of impacts, more complex functions still developing[3]					completion ahead of schedule but overlapping with impacts[4]					completion at assumed schedule
	ADVANCE						EARLY					TYPICAL
typical 5y schedule[0]												3:1
early performance (-1y)[1]											2.75:1	
early performance (-2y)[1]										2.5:1		
early performance (-3y)[1]									2.25:1			
early performance (-4y)[1]								2:1				
early performance (-5y)[1]							1.75:1					
advance performance (-1y)[1]						1.5:1						
advance performance (-2y)[1]	...				1.4:1							
advance performance (-3y)[1]	...			1.3:1								
advance performance (-4y)[1]	...		1.2:1									
advance performance (-5y)[1]	...	1.1:1										
advance performance (≥5y)[1]	1:1											
	≥5	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
	Mitigation Completion Relative to Initial Impact (Years)[0]											
Relative to VG project			2024	2025	2026	2027	2028*	2029	2030	2031	2032	2033^

	initial year of implementation, no performance evaluation
...	assumes initial mitigation implementation underway to ensure a minimum of 5y before final evaluation
[unsaturated color]	implementation underway, interim performance evaluations
[saturated color]	final year of implementation, assumes full performance achieved
*	assumes commencement of managed water level increases = time of impact
^	first post-operational target (= 8.5 ft WSE) monitoring event

[0] assumes a typical mitigation project's requirement of 5 years of monitoring ahead of final performance evaluation

[1] mitigation implemented in advance of project impacts may occur over a longer period (but not shorter than 5y) without necessarily affecting the applicable ratio reduction since mitigation delivery would still be ahead of a typical project's required timing (5y post-impact, for most cases)

[2] mitigation delivered more than 5 years in advance of project impacts would be assumed to have had sufficient time to develop some of the more complex functions typically provided by maturing ecosystems (e.g., biogeochemical cycling, reproduction of longer-lived species)

[3] mitigation delivered between 0-5 years in advance of project impacts would receive significant ratio reductions but the fraction above 1:1 reflects that while monitoring may no longer be necessary, the assumption at the end of such monitoring was that the ecosystem was on a self-sustaining trajectory but had not yet developed more complex functions that require longer timeframes

[4] mitigation underway but not fully delivered in advance of project impacts could be completed ahead of the typically assumed lag period, thus abbreviating temporal loss and warranting some reduction once complete

Figure 3

5-year Wetland Mitigation Delivery (Creation/Substantial Restoration)

	≥5	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
	completion ahead of impacts, more complex functions significantly developed[2]	completion ahead of impacts, more complex functions still developing[3]					completion ahead of schedule but overlapping with impacts[4]					completion at assumed schedule
	ADVANCE						EARLY					TYPICAL
typical 5y schedule[0]												4:1
early performance (-1y)[1]											3.67:1	
early performance (-2y)[1]										3.33:1		
early performance (-3y)[1]									3:1			
early performance (-4y)[1]								2.67:1				
early performance (-5y)[1]							2.33:1					
advance performance (-1y)[1]						2:1						
advance performance (-2y)[1]	...				1.8:1							
advance performance (-3y)[1]	...			1.6:1								
advance performance (-4y)[1]	...		1.4:1									
advance performance (-5y)[1]	...	1.2:1										
advance performance (≥5y)[1]	1:1											
	≥5	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
	Mitigation Completion Relative to Initial Impact (Years)[0]											
Relative to VG project			2024	2025	2026	2027	2028*	2029	2030	2031	2032	2033^

[hatched color]	initial year of implementation, no performance evaluation
...	assumes initial mitigation implementation underway to ensure a minimum of 5y before final evaluation
[unsaturated color]	implementation underway, interim performance evaluations
[saturated color]	final year of implementation, assumes full performance achieved
*	assumes commencement of managed water level increases = time of impact
^	first post-operational target (= 8.5 ft WSE) monitoring event

[0] assumes a typical mitigation project's requirement of 5 years of monitoring ahead of final performance evaluation

[1] mitigation implemented in advance of project impacts may occur over a longer period (but not shorter than 5y) without necessarily affecting the applicable ratio reduction since mitigation delivery would still be ahead of a typical project's required timing (5y post-impact, for most cases)

[2] mitigation delivered more than 5 years in advance of project impacts would be assumed to have had sufficient time to develop some of the more complex functions typically provided by maturing ecosystems (e.g., biogeochemical cycling, reproduction of longer-lived species)

[3] mitigation delivered between 0-5 years in advance of project impacts would receive significant ratio reductions but the fraction above 1:1 reflects that while monitoring may no longer be necessary, the assumption at the end of such monitoring was that the ecosystem was on a self-sustaining trajectory but had not yet developed more complex functions that require longer timeframes

[4] mitigation underway but not fully delivered in advance of project impacts could be completed ahead of the typically assumed lag period, thus abbreviating temporal loss and warranting some reduction once complete

Figure 4 10-year ESHA Mitigation Delivery	completion ahead of impacts, more complex functions significantly developed[2]	completion ahead of impacts, more complex functions still developing[3]										completion ahead of schedule but overlapping with impacts[4]										completion at assumed schedule
	ADVANCE											EARLY										TYPICAL
10y schedule[0]																						3:1
early performance (-1y)[1]																					2.875:1	
early performance (-2y)[1]																				2.75:1		
early performance (-3y)[1]																			2.625:1			
early performance (-4y)[1]																		2.5:1				
early performance (-5y)[1]																	2.375:1					
early performance (-6y)[1]																2.25:1						
early performance (-7y)[1]															2.125:1							
early performance (-8y)[1]														2:1								
early performance (-9y)[1]													1.875:1									
early performance (-10y)[1]												1.75:1										
advance performance (-1y)[1]											1.5:1											
advance performance (-2y)[1]	...									1.45:1												
advance performance (-3y)[1]	...								1.4:1													
advance performance (-4y)[1]	...							1.35:1														
advance performance (-5y)[1]	...						1.3:1															
advance performance (-6y)[1]						1.25:1																
advance performance (-7y)[1]					1.2:1																	
advance performance (-8y)[1]				1.15:1																		
advance performance (-9y)[1]			1.1:1																			
advance performance (-10y)[1]		1.05:1																				
advance performance (>10y)[1]	1:1																					
	>10	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
	Mitigation Completion Relative to Initial Impact (Years)[0]																					
Relative to VG project								2024	2025	2026	2027	2028*	2029	2030	2031	2032	2033^	2034	2035	2036	2037	2038

	initial year of implementation, no performance evaluation
...	assumes initial mitigation implementation underway to ensure a minimum of 10y before final evaluation
[unsaturated color]	implementation underway, interim performance evaluations
[saturated color]	final year of implementation, assumes full performance achieved
*	assumes commencement of managed water level increases = time of impact
^	first post-operational target (= 8.5 ft WSE) monitoring event

[0] assumes a mitigation project's requirement of 10 years of monitoring ahead of final performance evaluation

[1] mitigation implemented in advance of project impacts may occur over a longer period (but not shorter than 10y) without necessarily affecting the applicable ratio reduction since mitigation delivery would still be ahead of a typical project's required timing (10y post-impact, for most cases)

[2] mitigation delivered more than 10 years in advance of project impacts would be assumed to have had sufficient time to develop some of the more complex functions typically provided by maturing ecosystems (e.g., biogeochemical cycling, reproduction of longer-lived species)

[3] mitigation delivered between 0-10 years in advance of project impacts would receive significant ratio reductions but the fraction above 1:1 reflects that while monitoring may no longer be necessary, the assumption at the end of such monitoring was that the ecosystem was on a self-sustaining trajectory but had not yet developed more complex functions that require longer timeframes

[4] mitigation underway but not fully delivered in advance of project impacts could be completed ahead of the typically assumed lag period, thus abbreviating temporal loss and warranting some reduction once complete

Figure 5

5-year ESHA Mitigation Delivery (Enhancement)

	completion ahead of impacts, more complex functions significantly developed[2]	completion ahead of impacts, more complex functions still developing[3]					completion ahead of schedule but overlapping with impacts[4]					completion at assumed schedule
	ADVANCE						EARLY					TYPICAL
typical 5y schedule[0]												6:1
early performance (-1y)[1]											5.5:1	
early performance (-2y)[1]										5:1		
early performance (-3y)[1]									4.5:1			
early performance (-4y)[1]								4:1				
early performance (-5y)[1]							3.5:1					
advance performance (-1y)[1]						3:1						
advance performance (-2y)[1]	...				2.6:1							
advance performance (-3y)[1]	...			2.2:1								
advance performance (-4y)[1]	...		1.8:1									
advance performance (-5y)[1]	...	1.4:1										
advance performance (≥5y)[1]	1:1											
	≥5	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
	Mitigation Completion Relative to Initial Impact (Years)[0]											
Relative to VG project			2024	2025	2026	2027	2028*	2029	2030	2031	2032	2033^

	initial year of implementation, no performance evaluation
...	assumes initial mitigation implementation underway to ensure a minimum of 5y before final evaluation
[unsaturated color]	implementation underway, interim performance evaluations
[saturated color]	final year of implementation, assumes full performance achieved
*	assumes commencement of managed water level increases = time of impact
^	first post-operational target (= 8.5 ft WSE) monitoring event

[0] assumes a typical mitigation project's requirement of 5 years of monitoring ahead of final performance evaluation

[1] mitigation implemented in advance of project impacts may occur over a longer period (but not shorter than 5y) without necessarily affecting the applicable ratio reduction since mitigation delivery would still be ahead of a typical project's required timing (5y post-impact, for most cases)

[2] mitigation delivered more than 5 years in advance of project impacts would be assumed to have had sufficient time to develop some of the more complex functions typically provided by maturing ecosystems (e.g., biogeochemical cycling, reproduction of longer-lived species)

[3] mitigation delivered between 0-5 years in advance of project impacts would receive significant ratio reductions but the fraction above 1:1 reflects that while monitoring may no longer be necessary, the assumption at the end of such monitoring was that the ecosystem was on a self-sustaining trajectory but had not yet developed more complex functions that require longer timeframes

[4] mitigation underway but not fully delivered in advance of project impacts could be completed ahead of the typically assumed lag period, thus abbreviating temporal loss and warranting some reduction once complete

Figure 6

5-year ESHA Mitigation Delivery (Creation/Substantial Restoration)

	≥5	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
	completion ahead of impacts, more complex functions significantly developed[2]	completion ahead of impacts, more complex functions still developing[3]					completion ahead of schedule but overlapping with impacts[4]					completion at assumed schedule/ implementation on typical schedule following impacts	implementation delayed >5y following project impacts[5]					implementation delayed >10 years following impacts, or incomplete delivery w/ <3y meeting interim performance[6]				
	ADVANCE						EARLY					TYPICAL	DELAYED					SIGNIFICANTLY DELAYED				
delayed implementation (+>5y)																		TBD by ED or CCC, as determined				
delayed implementation (+5y)																	5.5:1					TBD
delayed implementation (+4y)																4.5:1					TBD	
delayed implementation (+3y)															4.5:1					TBD		
delayed implementation (+2y)														4:1								
delayed implementation (+1y)													3.5:1									
typical 5y schedule[0]												3:1										
early performance (-1y)[1]											2.75:1	...	3:1									
early performance (-2y)[1]										2.5:1		...		3:1								
early performance (-3y)[1]									2.25:1			...			3:1							
early performance (-4y)[1]								2:1				...				3:1						
early performance (-5y)[1]							1.75:1					...					3:1					
advance performance (-1y)[1]						1.5:1																
advance performance (-2y)[1]	...				1.4:1																	
advance performance (-3y)[1]	...			1.3:1																		
advance performance (-4y)[1]	...		1.2:1																			
advance performance (-5y)[1]	...	1.1:1																				
advance performance (≥5y)[1]	1:1																					
	≥5	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
	Based on Mitigation Completion Relative to Initial Impact (Years)																					
							Based on Mitigation Implementation and Performance Relative to Initial Impact (Years)															

	initial year of implementation, no performance evaluation
...	assumes initial mitigation implementation underway to ensure a minimum of 5y before final evaluation
[unsaturated color]	implementation underway, interim performance evaluations
[saturated greens and blues]	final year of implementation, assumes full performance achieved
[saturated orange]	increased ratio imposed given >5y delay in mitigation implementation
[saturated purple]	action TBD as determined by ED or Commission, given >10y delay in mitigation implementation or incomplete delivery w/ <3y performance and meeting interim criteria

[0] assumes a typical mitigation project's requirement of 5 years of monitoring ahead of final performance evaluation; implementation is expected to occur within 5 years of impacts but final performance may occur as late as 10 years due to implementation delays and/or extended performance periods necessitated by underperformance relative to final success criteria

[1] mitigation implemented in advance of project impacts may occur over a longer period (but not shorter than 5y) without necessarily affecting the applicable ratio reduction since mitigation delivery would still be ahead of project's required timing (5y post-impact, for most cases)

[2] mitigation delivered more than 5 years in advance of project impacts would be assumed to have had sufficient time to develop some of the more complex functions typically provided by maturing ecosystems (e.g., biogeochemical cycling, reproduction of longer-lived species)

[3] mitigation delivered between 0-5 years in advance of project impacts would receive significant ratio reductions but the fraction above 1:1 reflects that while monitoring may no longer be necessary, the assumption at the end of such monitoring was that the ecosystem was on a self-sustaining trajectory but had not yet developed more complex functions that require longer timeframes

[4] mitigation underway but not fully delivered in advance of project impacts could be completed ahead of the typically assumed lag period, thus abbreviating temporal loss and warranting some reduction once complete

[5] mitigation implemented more than 5y after project impacts commence would be considered delayed beyond what the original mitigation ratio accounted for and thus, imposes an annual increase of 0.5 acres per year

[6] mitigation that has not been implemented by 10y after project impacts commence, or has not been delivered with at least 3y meeting interim performance criteria, is considered significantly delayed and warrants reassessment by the Commission's Executive Director and upon their evaluation of the situation, potentially a return to the Commission for reconsideration

CALIFORNIA COASTAL COMMISSION
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May 24, 2024

To: Oceane Ringuette, District Supervisor, North Central Coast
From: Jeremy Smith PE, Staff Coastal Engineer
Technical Services Unit

Subject: **CDP Application 2-20-0663: *Vista Grande Drainage Basin Improvement Project***

Executive summary

As part of the proposed project, the existing Daly City outlet structure, which currently presents significant impacts to the enjoyment of and access along the sandy beach fronting the Fort Funston bluffs, would be removed. A new outlet structure would be constructed near the base of the existing bluffs. The applicant determined that wingwalls would be necessary to avoid more frequent costly maintenance and reduce the risk of the outlet structure behind undermined by natural shoreline processes. These wingwalls would extend approximately 170 feet along the base of the existing bluffs and connect to San Francisco's existing outlet wingwalls upcoast. While removing the existing structures on the beach would present an improvement to the public's ability to recreate and move along the sandy beach, the proposed wingwalls would inhibit the natural erosion of the bluffs behind them and cause the formation of an artificial bluff promontory. Such a promontory would extend further into the swash and surf zone as the bluffs on either side retreated, cutting off access along the sandy beach.

Materials Reviewed & Referenced:

Moffatt & Nichol (2017) *Coastal Engineering Study. Vista Grande Drainage Basin Improvement Project*. Prepared for McMillen Jacobs Associates. Prepared by Moffatt & Nichol, October 16, 2017.

Moffatt & Nichol (2019) *Vista Grande Coastal Impacts Memo*. Prepared for City of Daly City/Project Team. Prepared by Mads Jorgensen, Moffatt & Nichol, July 11, 2019.

McMillen Jacobs Associates / Brown and Caldwell / Moffatt & Nichol (2020) *Evaluation of Coastal Components*. Prepared for City of Daly City. Prepared by Moffatt & Nichol, Brown and Caldwell, and McMillen Jacobs Associates, May 2020

Treadwell & Rollo (2013) *Geotechnical Investigation and Geologic Evaluation Vista Grande Drainage Basin Improvements*. Prepared for Jacobs Associates. Prepared by Treadwell & Rollo, August 14, 2013.

Introduction & Background

CDP Application 2-20-0663 is a complex proposal spanning multiple jurisdictions by the City of Daly City (referred to as the City or the applicant in this memo). The project includes a variety of work but the focus of this memo is on the impacts from the proposed outlet structure and associated armoring. In this memo, I will first provide brief background on the subject site and relevant context related to the proposed armoring and coastal processes. Next, I will describe and assess the claims by the applicant about the need for the wingwalls and the impacts the wingwalls and the outlet structure will have on coastal access into the future. I will provide an analysis of when impacts to lateral access may become significant and discuss some important assumptions and considerations for evaluating coastal access along the beach in the project area.

The subject site is at the base of tall bluffs approximately 0.24 miles from the nearest vertical access point at Fort Funston. The subject site is the location of two outlet structures draining two different stormwater systems: the northern one constructed by San Francisco and the southern by Daly City. The Daly City outlet and tunnel were originally constructed in the mid-to-late 1890s and replaced with the existing outlet structure around 1951. Due to erosion of the bluffs, the tunnel leading to the outlet structure has periodically become exposed and been reinforced by the City, which has resulted in a structure that extends approximately 80 feet onto the sandy beach from the base of the bluffs. The northernmost outlet structure, owned by the City and County of San Francisco, was constructed in 1956 and currently serves as an overflow to the City's combined sewer-stormwater drainage system. The San Francisco outlet is protected by low profile wingwalls which have slowed the erosion of the bluffs behind them and caused the formation of a promontory.

The Fort Funston bluffs are largely made up of Merced Formation material which is relatively friable and vulnerable to both marine and subaerial erosion and span approximately one mile from the southern extent of the Great Highway in the north to the steep sand ladder access point in the south. Access from the north occurs via South Ocean Beach, which has chronic erosion issues. In the future, San Francisco is considering constructing vertical access stairs near the southern edge of South Ocean Beach. The next vertical access point occurs approximately a half mile south of Ocean Beach via a relatively informal trail constructed into a historic drainage gully. Vertical access from the south occurs via the steep sand ladder trail about 1,300 feet from the Daly City outlet structure.

The beach is highly dynamic and varies seasonally as waves and currents move sand alongshore as well as on and offshore across the beach profile. Beach widths vary from 0 to 140 feet. During intense wave conditions, waves can reach the base of the bluffs and cause erosion at the toe of the bluffs. Due to the large bluff heights, seismic activity and subaerial erosional processes can also cause bluff failure, depositing large amounts of bluff material onto the beach where it is ultimately sorted by waves, with sandy material contributing to the San Francisco Littoral Cell (which spans from the Golden Gate to San Pedro Point in Pacifica).

The proposed wingwalls would be relatively low profile, extending to approximately 14 ft NAVD88. The intention of the wingwalls, as described by the applicant's consulting coastal engineers, Moffatt & Nichol, is to protect the base of the bluffs and prevent undermining of the newly constructed tunnel. To avoid end effects and the issues those would pose to the tunneled infrastructure, the wingwalls would extend to connect to San Fransisco's wingwalls about 58 feet to the north, and 105 feet to the south. The wingwalls would include riprap fill placed landward of the walls to avoid erosion issues caused by wave overtopping and buttress the backside of the walls. A reinforced concrete apron would also be constructed at the base of the outlet structure to protect the supporting piers for the outlet structure and new effluent pipelines when sand levels are low, and to facilitate lateral access along the beach over the concrete apron.

Assessment of Analysis & Claims by the Applicant's Consultants

<u>Wingwalls</u>

The 2017 Moffatt & Nichol Coastal Engineering Study assesses the potential to include wingwalls as part of the proposed replacement outlet structure, specifically, the frequency of necessary maintenance with and without the wingwalls. The study concludes that the new outlet structure without wingwalls would require maintenance approximately every 10 years. With the addition of wingwalls, this maintenance needs would be reduced to approximately every 30 years.

The study also concludes that the wingwalls are required to protect the outlet and tunnel from scour and reduce the frequency of major repairs. While it seems reasonable that some level of focused measures are needed to protect the outlet structure and tunnel from being undermined by the loss of beach sand under storm conditions, maintenance and periodic reconstruction can be considered technically feasible alternatives to the larger scale armoring in the proposed design.

The maintenance and reconstruction that would be necessary without the wingwalls would likely require a significant effort by the applicant. As sea level rise increases the exposure of the structure and surrounding bluffs to wave attack, the frequency of maintenance will increase, while also becoming increasingly difficult in terms of being able to mobilize and stage equipment at the outlet site. Reaching the site with heavy equipment involves driving equipment for several miles on sandy beach, and already is limited to favorable sand levels, tides, and wave conditions. With expected future sea level rise, all of these factors will become increasingly constraining to site access.

While addressing bluff erosion through more frequent maintenance would be a significant effort, the existing outlet structure and tunnel has been maintained without armoring for decades, further demonstrating that an alternative without wingwalls is technically feasible. As erosion starts to expose the tunnel, it is likely that intermediate repairs will be necessary to reinforce the exposed portions of the tunnel at approximately the same frequency that has been done with the existing tunnel (approximately every 5-10 years).

Effects on public access

The proposed project would significantly improve access at the site. Currently, the outlet structure and exposed tunnel extend over 80 feet from the current bluff toe out onto the beach. During low sand levels and/or energetic wave conditions, wave swash extends well landward of the seaward tip of the outlet structure, preventing the public from safely walking along the sandy beach.

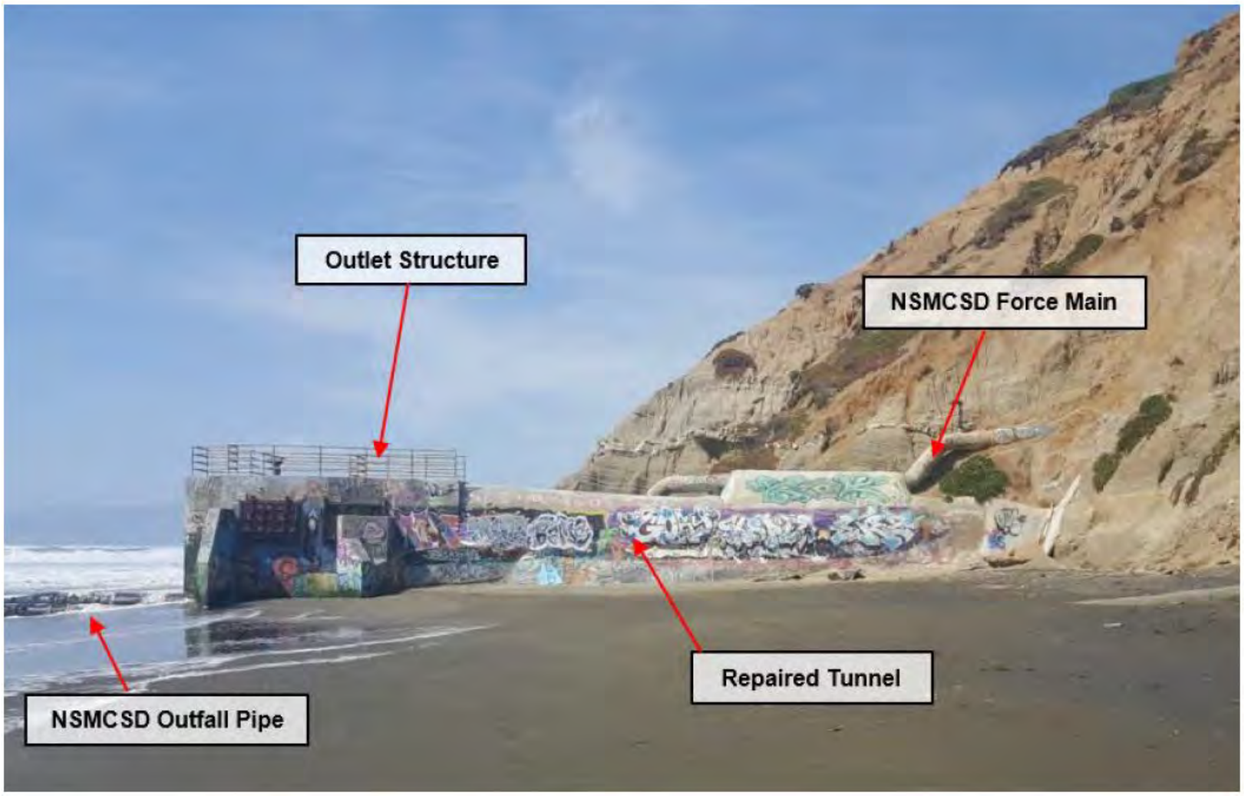

Figure 1. Vista Grande outlet structure (*Figure 3* from McMillen Jacobs Associates, Brown & Caldwell, Moffatt & Nichol, 2020)

By removing the existing outlet structure and tunnel and reconstructing the outlet as far seaward as possible, the proposed project would remove what is currently a significant barrier to lateral public access along the beach with few vertical access points.

The Moffatt & Nichol 2017 Coastal Engineering Study and 2019 Coastal Impacts Memo assess the proposed project compared to existing conditions and to scenarios with and without wingwalls. Moffatt & Nichol claim that the proposed project with wingwalls is substantially better for public access along the beach than a project without wingwalls. This claim comes from analysis summarized in the 2019 Coastal Impacts Memo in which Moffatt & Nichol model a range of beach widths at the project site as the bluff and beach retreat over time, primarily driven by sea level rise. The analysis has one major flaw: the analysis did not consider beach retreat as it would occur with the unarmored bluffs retreating naturally up and down coast of the outfall. With wingwalls, the armored bluffs flanking the outfall would form a promontory that would stick out from an otherwise relatively uniform stretch of bluff at Fort Funston. This is demonstrated by the existing promontory that has formed as a result of wave sheltering from San Francisco's wingwalls. Instead, the analysis in the memo appears to show little recession of the beach fronting the wingwalls even under relatively high amounts of sea level rise (6.9 feet by 2100). While the report mentions the analysis considered beach recession according to the "Bruun Rule[1]," the actual results of the analysis appear to underpredict the beach recession that would be expected to occur in response to sea level rise using this method. Plate 10 from (Moffatt & Nichol, 2019) shows little landward retreat (visually estimated at approximately 20 feet by 2100) of the beach profile, even with 6.9 feet of sea level rise. In contrast, according to the Bruun Rule, even a relatively steep beach (steeper beaches retreat less than mildly sloped beaches for the same amount of sea level rise) with a slope of 10:1 (H:V) would experience 69 feet of landward recession with 6.9 feet of SLR. Furthermore, there are few physical reasons to explain why a sandy beach fronting a bluff promontory would be substantially wider than the beach up- or downcoast. The relative size of the promontory (approximately 200 feet wide) is such that longshore diffusion would work to keep the sandy shoreline roughly in-line with the shoreline on either side as illustrated in the figure below.

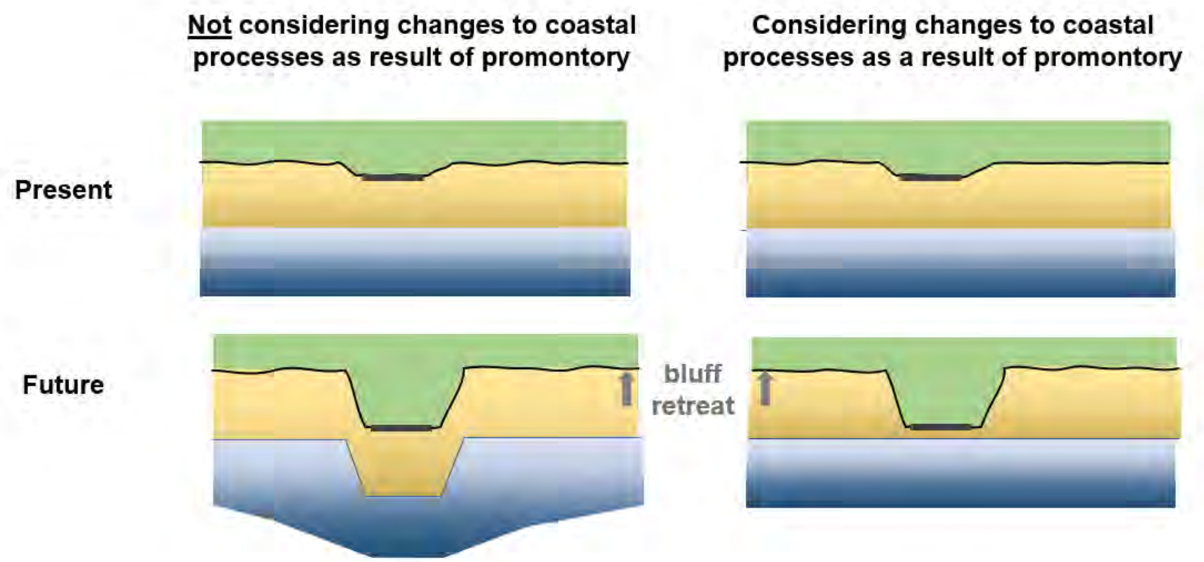

Figure 2. Diagram demonstrating difference of assuming shoreline stays continuous with formation of promontory (right) and not (left).

Staff had noted this issue with Moffatt & Nichols' 2019 memo in a non-filing letter dated July 16, 2021, to which the applicant's representative, ESA, responded in a letter from October 11, 2021:

> *We are in agreement that the shoreline position of the beach in front of a relatively small promontory will not deviate substantially from the beaches up and downcoast of the promontory. As pointed out in the*

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[1] The Bruun Rule refers to the relationship between sea level rise and shoreline recession based on equilibrium profile theory. While the Bruun Rule is, in most cases, an oversimplification, it is nonetheless a common approach used to estimate the response of sandy beaches to sea level rise.

Commission staff's comments regarding Coastal Components, this is demonstrated at the CCSF outlet where the wingwalls have protected the bluff but not impacted the shoreline position. The M&N 2019 memo was focused on exploring potential outcomes in the event of extreme sea-level rise. Wave action was not a focus area of the analysis as it is not possible to reliably predict wave conditions that could occur in combination with tide and time of day. Access management along the Fort Funston shoreline will to a large extent be up to the National Park Service – as manager of Fort Funston as a whole, including the various conditions that may present safety concerns within the park. In addition, as under current conditions along segments of shoreline to the north and south of the project site where access is constrained, it will be up to individual beachgoers to decide based on the site conditions whether safe passage is possible, and they should rely on advisories issued and broadcast for the area.

Without updated information from the applicant, it appeared necessary to reexamine the 2019 memo to determine the potential impacts to public access from a project with wingwalls. Using the bluff retreat rates and beach profile estimated by Moffatt & Nichol, I concluded that a promontory formed by the armoring of Fort Funston at the site of the outlet structure would result in the blocking of lateral access during periods of low sand conditions and high tides (not considering waves) by the 2030s, assuming sea level rise follows the medium-high risk aversion curve (0.8-1.3 feet, 99.5th percentile projection outlined in the 2018 Ocean Protection Council Sea Level Rise Guidance). During high sand levels, the promontory would result in blocked lateral access as soon as the 2070s during high tides and with average wave conditions. In other words, with modest amounts of sea level rise (1-2 feet), the promontory caused by armoring the bluffs could prevent the public from walking along the beach on most days in the winter. With higher amounts of sea level rise (3-5 feet), the promontory could block lateral access almost every day of the year.

To arrive at those conclusions, I used the bluff retreat rates and estimated beach widths for the high sand and low sand beach profiles from the 2019 Moffatt & Nichol Memo. Because the bluffs up- and downcoast from the proposed wingwalls would be unarmored, they would continue to erode naturally from marine and non-marine forcings. As the bluffs erode, the beach profile is also expected to retreat landward. Assuming the beach and bluff system is in an equilibrium condition, the beach profile retreat would equal the bluff retreat, effectively maintaining its current width, but at a more landward position. Because the wingwalls would form a bluff promontory by shielding a 170-foot wide stretch of bluffs, the beach widths at the promontory would recede, as the equilibrium beach profile shifts landward on either side, and the relatively rapid longshore diffusion maintains near continuous linear nearshore contours. To estimate these reduced widths, I took the 2020 beach widths for the proposed new outlet structure (without wingwalls) and for each year/sea level rise amount, subtracted the estimated bluff retreat from each of the widths.

However, in addition to the equilibrium beach profiles shifting landward to match the bluff retreat, they are also expected to both vertically shift (by the amount of sea level rise) and retreat landward according to the beach slope (i.e., the Bruun Rule). By assuming a steeper beach slope of 10:1 (horizontal to vertical), this retreat is equal to 10 times the amount of sea level rise. Actual beach slopes at the site were estimated by Moffatt & Nichol to range from 11:1 to 28:1 seasonally, indicating the assumption of 10:1 may represent the lower end of the sea level rise-induced beach retreat. This additional beach retreat was further subtracted to the reduced widths from above.

Moffatt & Nichol estimated beach widths for a range of sand levels and for four tidal datums (MHHW, MHW, MLW, and MLLW). The four tidal datums represent tidal averages of the daily higher high tide, daily high tides, daily low tides, and daily lower low tide respectively. They represent still water levels (i.e., they don't consider the additive effects of waves on average water levels experienced on coastal beaches). To account for the effects of waves, an assumed one foot increase to water level elevations was considered to capture the average contribution of waves to average water levels experienced in the swash zone. Again, considering a relatively steep beach slope of 10:1, this one foot addition would translate to 10 feet less of beach width available for the public to traverse along the beach.

Considering these adjustments together results in the following projected beach widths over time for the sea level rise scenario considered by Moffatt & Nichol (the medium-high risk aversion curve for San Francisco from Ocean Protection Council's 2018 guidance):

		Projected Beach Widths (feet) with Sea Level Rise							
		High Sand Beach Conditions				Low Sand Beach Conditions			
Year	SLR (feet)	MHHW	MHW	MLW	MLLW	MHHW	MHW	MLW	MLLW
2020	0	210	220	356	430	40	55	110	161
2050	1.9	104	114	250	324	0	0	4	55
2075	4	16	26	162	236	0	0	0	0
2100	6.9	0	0	38	112	0	0	0	0

Beyond the assumptions used in the above analysis, there are a few additional assumptions that are worth expanding on. First, the 2020 beach widths for the project without wingwalls that I ultimately modified are presumably measured from the seaward edge of the new outlet structure which extends approximately 10 feet from the toe of the bluff in their cross sections. Because it was unclear what exact landward edge Moffatt & Nichol used in their analysis, I assumed the beach widths were equivalent to the beach widths (measured from the toe of the bluff) along the natural bluffs up- and downcoast.

Second, because Moffatt & Nichol evaluated cross sections at the outlet structure, this analysis effectively assumes the outlet structure is the furthest seaward that the armoring-induced promontory extends. In reality, the proposal includes wingwalls that would be in line with the base of the existing bluffs, which, in this location, are out of alignment with most of the natural bluffs up and down coast due to an existing promontory feature caused by the existing wingwalls protecting San Francisco's outlet structure just upcoast, and wave-sheltering effects caused by the approximately 80 foot long existing exposed outlet structure and tunnel. When analyzing the effects of armoring, it is common to focus the analysis on proposed structures, effectively ignoring any existing or potential armoring outside the scope of the project. In reality, if San Francisco's wingwalls remain and continue to slow armoring of the bluff behind them, because of their more seaward position than the proposed outlet structure, lateral access would first be constrained by San Francisco's upcoast wingwalls. This impact would likely occur sooner than the impacts analyzed above and possibly in the very near future, as the outlet structures and associated promontory make lateral access difficult during low sand levels at present.

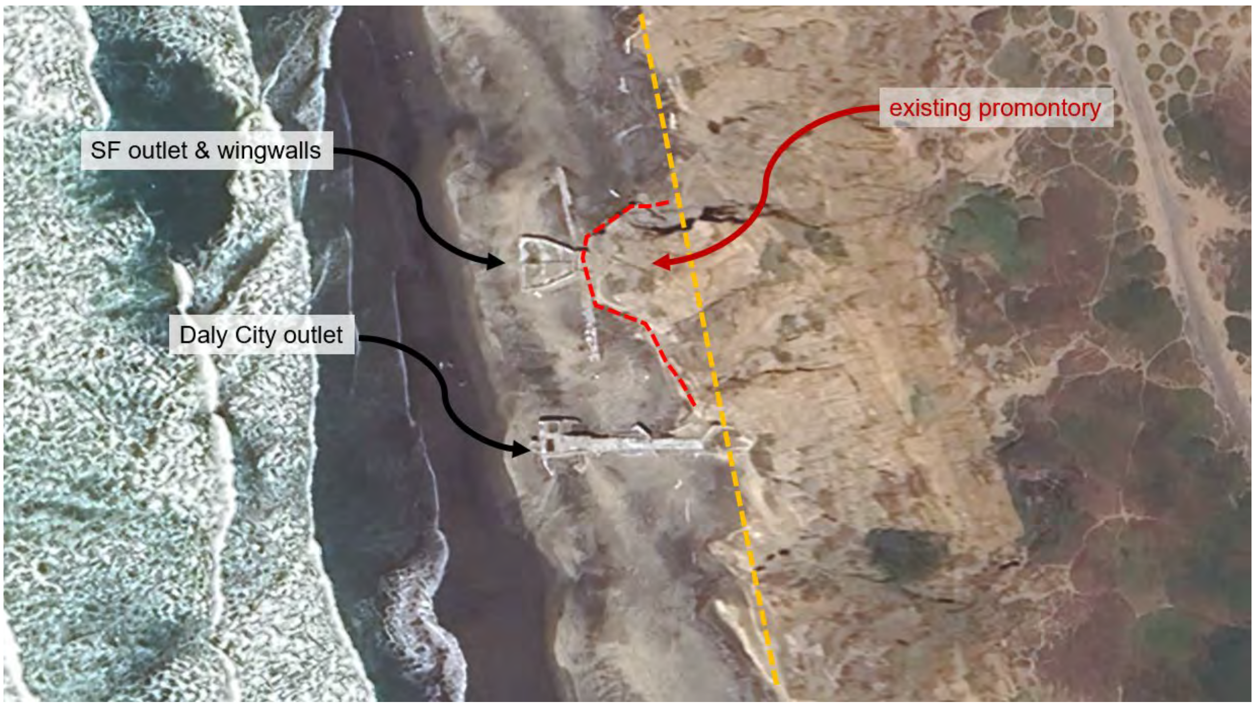

Figure 3. Satellite imagery from July, 2023 illustrating current conditions with existing promontory noted in red and approximately bluff orientation in gold (Google Earth)

Conclusion

The Vista Grande Drainage Basin Improvement Project includes replacing the existing Daly City outlet structure, tunnel, and force mains with a new outlet structure, tunnel, with integrated wastewater gravity mains. The removal of the existing Daly City outlet structure would improve the enjoyment of and access along the sandy beach fronting the Fort Funston bluffs by removing a significant barrier to lateral access. The applicant has determined that wingwalls protecting the bluff on either side of the new outlet structure would be necessary to avoid more frequent costly maintenance and reduce the risk of the outlet structure behind undermined by natural shoreline processes. These wingwalls would extend approximately 170 feet along the base of the existing bluffs and connect to San Francisco's existing outlet wingwalls upcoast. The proposed wingwalls would inhibit the natural erosion of the bluffs behind them and cause the formation of an artificial bluff promontory. Such a promontory would extend further into the swash and surf zone as the bluffs on either side retreated, cutting off access along the sandy beach. The formation of this promontory was not adequately considered in the applicant's submittals. I used information provided in the applicant's consultant's analyses to conduct an adjusted analysis that better accounted for impacts to lateral access from the formation of a promontory at the outlet structure. While the analysis included several simplifying assumptions, I demonstrated that these assumptions, on the whole, are appropriate for an analysis of impacts to lateral access. The results of my analysis indicate that a promontory formed by the armoring of Fort Funston at the site of the outlet structure would result in the blocking of lateral access during periods of low sand conditions and high tides (not considering waves) by the 2030s (assuming 0.8-1.3 feet of sea level rise). With modest amounts of sea level rise (1-2 feet), the promontory caused by armoring the bluffs could prevent the public from walking along the beach on most days in the winter. With higher amounts of sea level rise (3-5 feet), the promontory could block lateral access almost every day of the year.

Jeremy Smith, PE

Land Valuation

Address	Lot Size (sq. ft.)	Sale Price	Sale Date	Price/Sq. Ft.
3 Skyline Dr.	5,183	$1,100,000	4/7/2022	$212.23
30 Roslyn Ct.	3,672	$1,600,000	9/14/2022	$435.73
62 Seacliff Ave.	3,400	$1,180,000	9/29/2020	$347.06
39 Skyline Dr.	3,162	$1,150,000	11/16/2020	$363.69
92 Roslyn Ct.	3,741	$1,300,000	9/29/2022	$347.50

Average Cost/Square Foot: $341.24