January 2019
Lake Temescal Dredging and Restoration Project

Lake Temescal Dredging and Restoration Project Feasibility Assessment

Prepared for the East Bay Regional Park District

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ABBREVIATIONS

--	not applicable
µg	microgram
Anchor QEA	Anchor QEA, LLC
CEQA	California Environmental Quality Act
cfs	cubic feet per second
cy	cubic yard
EBRPD	East Bay Regional Park District
EIR	Environmental Impact Report
ESL	Environmental Screening Level
g	gram
Horizon	Horizon Water and Environment, LLC
IS	Initial Study
L	liter
LS	lump sum
m^2	square meter
mg	milligram
N	nitrogen
NAVD88	North American Vertical Datum of 1988
P	phosphorous
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEL	Probable Effect Level
PG&E	Pacific Gas & Electric Company
RDS	rapid dewatering system
RWQCB	Regional Water Quality Control Board
STLC	Soluble Threshold Limit Concentration
TCLP	Toxicity Characteristic Leaching Procedure
TEL	Threshold Effect Level
TTLC	Total Threshold Limit Concentration
USEPA	U.S. Environmental Protection Agency

1 Introduction

1.1 Objective and Scope of Work

The purpose of the proposed Lake Temescal dredging and restoration project (project) is to improve the water quality of the lake and provide long-term sediment and water quality management features. This feasibility assessment identifies and outlines three lake restoration options, identifies alternatives for each restoration option, and assesses the feasibility of alternative implementation and long-term performance to determine project recommendations. Development of the restoration alternatives and the collection of the supporting survey and sediment characterization data presented in this report was a collaborative effort between the East Bay Regional Park District (EBRPD), Anchor QEA, LLC, and Horizon Water and Environment, LLC (Horizon), with support from Alex Horne, PhD, Hultgren-Tillis Engineers, and eTrac, Inc.

For the project to be both efficient and sustainable, it must address both current and future water quality impacts. To address current impacts, a large volume of sediment (associated with ongoing sediment input into Lake Temescal) should be removed from the lake to restore water depth and proper lake biology. To address future impacts, incoming sediment and nutrient loads should be intercepted before entering the lake. To meet those objectives, the overall scope of work for this feasibility assessment included the following tasks:

- Conduct bathymetric survey of Lake Temescal and limited topographic survey of surrounding upland features
- Carry out limited exploratory sediment testing program to characterize sediment quality in the lake and assess potential lake sediment reuse or disposal sites
- Identify conceptual design requirements for the following three restoration options:
  - Dredging, including identification of a target water depth to enhance water quality and estimation of resulting dredging volumes
  - Treatment wetland construction, including conceptual wetland size and elevation to obtain optimal nutrient removal from incoming sediment load
  - Existing sediment basin expansion by estimating future sedimentation rates
- Conduct preliminary screening of construction technologies for the identified dredging alternatives as they would apply for implementation at Lake Temescal
- Develop recommended alternatives for each restoration option
- Prepare order-of-magnitude cost estimates for the recommended restoration alternatives
- Recommend next steps to support selection of a design approach, preparation of a preliminary design, and initiate regulatory agency coordination and planning

1.2 Available Site Literature and Records

The following reference materials were used to support preparation of this report. Full citations for all references are included in Section 12.

- Information provided by EBRPD
  - Annual sediment basin excavation records (2006 to 2018)
  - Draft Environmental Impact Report (EIR) referencing excavation from the 1980s and 1990s
  - Water quality data from 2016
  - Nutrient monitoring data from 2017 and 2018
  - Communications with EBRPD staff and site managers regarding site history, operations, and planning
- Recently developed information (in association with this investigation)
  - 2018 bathymetric and topographic survey
  - 2018 exploratory sediment characterization effort
- Publicly available information
  - Historical Lake Temescal reports from the U.S. Environmental Protection Agency (USEPA) and EBRPD
  - Local groundwater and watershed studies
  - Technical and academic publications

2 Site Conditions

2.1 Historical Site Conditions

Lake Temescal is a 13-acre artificial lake in northeastern Oakland, initially constructed in the late 1860s to store drinking water. Various reports indicate that the lake had an initial depth between 60 and 80 feet (USEPA 1980; USGS StreamStats 2018).

The lake drains 2.7 square miles of the Oakland Hills watershed, which is developed primarily with single-family residential units. Roughly one-third of the watershed is forested, while 14% is covered with impervious surfaces (USGS StreamStats 2018). In the mid-1930s, the original dam height was decreased to its current elevation and the lake was opened to the public as part of the EBRPD park system for recreational use (EBRPD 2018). The lake remains one of the most popular parks within the EBRPD system, offering visitors opportunities for recreation and wildlife viewing. The park includes a perimeter walking trail, numerous picnic tables and benches, three fishing docks, ample open grass areas, and a sandy beach adjacent to the designated swimming area. Lake Temescal and the vicinity are shown in Figure 2-1.

2.1.1 Lake Sedimentation Impacts to Water Quality

Lake sedimentation can be traced back to the earliest known bathymetric survey in 1907, which indicated that the lake depth had reduced by approximately 36 feet since its construction (Peoples Water Company 1907). In the 1960s and 1970s, large-scale freeway and residential development occurred within the lake's watershed. During this time, EBRPD noticed a significant impact to water quality, which began to impair recreational uses of the lake. Algae blooms increased, clarity decreased, and sedimentation was exacerbated, which was linked to the increased runoff (USEPA 1980).

2.1.2 Historical Lake Maintenance and Restoration Efforts

Dredging was reported to have occurred in 1963 and 1968; however, the specific dredging locations and depths are unknown. It is estimated that between 71,000 and 132,000 cubic yards of sediment were deposited in the 10 years following the 1963 dredging event, and the lake water depth had been reduced to 18 feet by 1973 (EBRPD 1978).

In 1976, the Alameda County Health Department mandated that swimming access be permitted only pending monthly confirmation of acceptable bacteriological quality. Later the same year, EBRPD applied for and was awarded a Clean Lakes Demonstration Grant from USEPA to plan and construct a restoration project to improve water quality and reduce costs associated with the long-term maintenance dredging. The initial restoration plan included dredging the lake, bypassing seasonal stream flows to control coliform bacteria in the summer and reduce sediment influx in the winter, and creating an in-water dike to cordon off and transform the upstream third of the lake into a large sediment collection basin for the Caldecott and Temescal Creek inlets. The in-lake sediment collection basin project was ultimately not constructed because it was determined that the lake bed sediment could not support the proposed containment rock dike and that reuse of the lake sediment would not be suitable for dike construction (USEPA 1980).

The resulting final design for the restoration project included dredging, creek flow diversion for park irrigation, and construction of sediment basins upstream of the Caldecott and Temescal inlets to intercept sediment before its deposition in the lake. In 1979, the project was constructed and 47,200 cubic yards of sediment were mechanically dredged from the lake and trucked to other EBRPD properties for use as fill material. The Caldecott and Temescal creek sediment basins were excavated, and a pump station was built.

The lake re-opened for swimming following construction. However, according to a 1980 USEPA Capsule Report (USEPA 1980), the restoration project did not appear to have significantly reduced nutrient content, and blue-green algae persisted. It is likely that the nutrient and algae issues persisted for the following reasons:

1. The dredging event achieved only 50% to 75% of the ideal water depths (as proposed in Section 3 of this report). Thus, the lake continued to experience warmer water temperatures and greater mixing.
2. Nutrient-laden sediment likely continued to enter the lake in large quantities, in particular from Caldecott Creek, based on assessment of the sediment pond capacity, maintenance history, and expected sediment transport for the sub-watershed (see Section 5).
3. No continuous nutrient removal system, such as a treatment wetland, was added to intercept incoming nutrient loads from Caldecott or Temescal Creeks before entering the lake.

Aside from the various dredging and restoration projects implemented in 1979, the USEPA Capsule Report noted that watershed management was also implemented in compliance with the 1979 EBRPD *Lake Temescal Pollution Identification and Source Control Program* (USEPA 1979). Overall enforcement of the program is the responsibility of the City of Oakland and Alameda County, as the watershed extends far beyond EBRPD property. Unfortunately, the report could not be located and continued implementation was not confirmed.

Table 2-1 contains a summary of the known changes in lake conditions over time due to sedimentation, dredging, and other maintenance activities, including the information described above.

Table 2-1
Lake Temescal Volume, Sedimentation, Dredging, and Maintenance History

Year	Event	Maximum Depth (feet)	Average Depth	Volume (acre-feet)	Volume Dredged (cubic yards)	Deposition (cubic yards)	Source
1866–1869	Dam constructed	80					USEPA 1980
1869	Dam completed (80 to 85 feet)			552			Norfleet 1998
1872	Dam raised to 105 feet						Norfleet 1998
1907	Bathymetric survey	36					Peoples Water Company 1907
1934	Dam lowered by 40 feet						Norfleet 1998
1939	Sand placed on the beach					200	Oakland Tribune 1939
1963 (September)	Bathymetric survey	27	13.7	150.2			EBRPD 1978 (DEIR)
1963	Dredging				40,000		EBRPD 1978 (DEIR)
1968	Dredging				40,000		EBRPD 1978 (DEIR)
1973		18	10.5	112.1			USEPA 1980; EBRPD 1978
1962–1973	Freeway and residential development in watershed					71,000–132,000	USEPA 1980; EBRPD 1978 (DEIR)
1973–1978	-					25,000	EBRPD 1978 (DEIR)
1978		16	9	96.6			EBRPD 1978 (DEIR), Oakland Tribune
1979	Dredging and construction of sediment basins				47,200		USEPA 1980, EBRPD 1993
1981–1993	Maintenance, approximately 1,500 cubic yards every 2 years				750 per year		EBRPD 1993
1991	Oakland Firestorm, second detention pond added						Booker et al. 1993
2006–2017	Sediment basin maintenance				~220 per year		EBRPD 2018
2017	Sediment basin maintenance			102	600		EBRPD 2017

2.2 Existing Site Conditions

2.2.1 Lake Bathymetry and Vertical Datum

A multibeam bathymetric survey was performed in Lake Temescal in December 2017, and is included as Appendix A. Some topographic measurements were also included to capture various upland features, including the shoreline, sediment basins, and earthen dam. The results of the survey indicate that the maximum water depth of the lake is approximately 18 feet at the northern portion near the dam, 14 feet in the central portion, and 16 feet in the southern portion near the Temescal Creek inlet.

The vertical datum for the survey is U.S. survey feet, referencing the North American Vertical Datum of 1988 (NAVD88).

2.2.2 Investigative Sediment Analysis

Exploratory sediment sampling and testing were conducted in 2018 to evaluate the general sediment quality in the event of future dredging. The sediment was characterized in relation to several potential reuse or placement sites, including wetland construction at the lake, on-site or off-site upland reuse, and disposal at local landfill facilities. The sampling program was intended to be a preliminary investigation to determine general sediment quality at the site and was not designed to meet regulatory or landfill screening requirements. A more comprehensive sampling and testing effort is required to obtain necessary regulatory approvals and to support engineering design efforts. It is anticipated that a comprehensive effort would involve at least 12 to 16 core samples extending to the proposed dredging elevation. If elevated concentrations of certain lake sediment constituents are a concern, the Regional Water Quality Control Board (RWQCB) and USEPA may also require individual characterization of each core as opposed to the common practice of permitting homogenization of multiple cores into one composite for testing. Order-of-magnitude costs for these potential investigation scenarios are included in Section 7.

The sample collection program and the physical and chemical results are summarized below. The complete sampling program and testing results can be found in the June 21, 2018, memorandum "Lake Temescal Exploratory Sediment Sampling and Analysis Report," from Anchor QEA to EBRPD (Anchor QEA 2018). This memorandum is included as Appendix B, excluding Attachment D: Laboratory Report because of its length.[1]

[1] The full sampling and analysis report, including Attachment D, was provided to EBRPD in June 2018.

2.2.2.1 Sample Collection

Sediment cores were collected from three stations within the lake: near the dam (LT-01); near the Caldecott Creek inlet (LT-02); and near the Temescal Creek inlet (LT-03). Sample locations are shown on Figure 2-2. Cores were collected using a vibracore, and refusal was met between approximately 12.9 and 18.4 feet below the existing mudline. Due to losses during core retrieval, between approximately 9.9 and 14.0 feet of sediment were ultimately recovered per core and sent to the laboratory for characterization. Sediment from the full length of each retrieved core was homogenized to create a vertical composite for physical, chemical, and biological characterization.

2.2.2.2 Physical Characterization

The grain size of each of the three homogenized cores is shown Table 2-2. LT-01 consisted primarily of fines (95.7% silt and clay), while Stations LT-02 and LT-03 had a significant amount of fine to coarse sand (62.1% and 54.8%, respectively). Although the samples were limited, this suggests that sediment is finer to the north of the lake and sandier near the creek inlets.

Table 2-2
2018 Investigative Sediment Analysis: Grain Size

Element	LT-01	LT-02	LT-03
Sand (Medium/Coarse)	--	17.0%	7.4%
Sand (Very Fine/Fine)	4.3%	45.1%	47.4%
Fines (Silt/Clay)	95.7%	37.9%	45.2%

The USEPA 1980 Capsule Report noted that three borings were collected and analyzed from various locations of the lake in 1977. The borings were reported to extend down to 33 feet below the mudline. The borings included identification of soft clays and silts with low bearing capacity (USEPA 1980). This information is consistent with the sediment at LT-01 but does not represent the higher sand content shown in LT-02 and LT-03. Prior to completion of engineering design, a more thorough analysis of the grain size at various lake regions and at different depth intervals should be performed to evaluate the sediment behavior for dredging and dewatering. Additionally, to minimize the risk of significant settlement or failure due to construction of a wetland or other weighted element in the lake basin, more detailed geotechnical analysis should be performed. The collection of cores for grain size and geotechnical analysis can be combined with the sampling work required for the comprehensive sediment characterization effort. Order-of-magnitude costs for completion of this work are included in Section 7.

2.2.2.3 Chemical Analysis

The three composited 2018 core samples were tested for various chemical constituents and compared to common thresholds and guidance values for the following end uses:

- Wetland cover: on-site reuse of dredged sediment to create treatment wetlands
- Upland placement: on- or off-site reuse as opportunistic fill
- Landfill disposal: off-site disposal at a landfill

The following sections describe the thresholds applied for each end use and summarize the exceedances identified based on laboratory analysis.

2.2.2.3.1 Wetland Cover Assessment

Wetland cover suitability is measured using the following thresholds:

- Threshold Effect Levels (TELs): Indication that adverse effects may occur due to exposure, but the sediment is not necessarily toxic
- Probable Effect Levels (PELs): Indication that adverse effects are more likely to occur due to exposure

Table 2-3 summarizes the constituents that exceeded the TEL and PEL values for wetland cover. All three samples exceeded TEL for chromium, lead, nickel, various other metals, polycyclic aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyl (PCB) congeners. However, exceedances of PEL varied among those constituents for each sample. In general, metals and PCBs were highest in LT-02, and PAHs and pesticides were highest in LT-03.

Table 2-3
Summary of Threshold Effect Level and Probable Effect Level Exceedances for Wetland Cover

	LT-01		LT-02		LT-03	
Element	**TEL**	**PEL**	**TEL**	**PEL**	**TEL**	**PEL**
Chromium	X		X	X	X	
Lead	X		X	X	X	
Nickel	X	X	X	X	X	X
Other Metals	X		X		X	
PAHs	X		X		X	
Pesticides	X	X	X	X	X	X
PCB Congeners	X		X		X	

2.2.2.3.2 *Upland Placement and Reuse Assessment*

Upland placement suitability is measured by Environmental Screening Levels (ESLs), which are linked to the potential impacts as regulated by the San Francisco RWQCB.

Table 2-4 summarizes the constituents that exceeded the ESL values for upland placement. Arsenic, lead, dimethyl phthalate, and the PAH benzo(a)pyrene exceeded ESL in all three samples. However, none of the samples measured significant exceedances.

Table 2-4
Summary of Environmental Screening Level Exceedances for Upland Placement

Element	LT-01	LT-02	LT-03
Arsenic	X	X	X
Lead	X	X	X
Dimethyl phthalate	X	X	X
PAH (benzo[a]pyrene)	X	X	X

2.2.2.3.3 *Landfill Disposal Assessment*

Landfill suitability is measured by the following thresholds:

- Total Threshold Limit Concentration (TTLC): Bulk concentration test to determine whether the sediment is hazardous waste
- Soluble Threshold Limit Concentration (STLC): Leachate testing required to determine whether the sediment is hazardous waste; the sample is diluted at a 10:1 ratio for analysis (10x)
- Toxicity Characteristic Leaching Procedure (TCLP): Leachate testing required to determine whether the effluent will contain hazardous waste; the sample is diluted at a 20:1 ratio for analysis (20x)

Table 2-5 summarizes the constituents that exceeded the TTLC, STLC, and TCLP values for landfill disposal. The thresholds were based on Title 23 of the California Code of Regulations and 40 Code of Federal Regulations 261; however, each landfill may have unique acceptance criteria. No samples exceeded TTLC for any constituents. Lead exceeded the STLC value in all three samples, chromium in LT-01 exceeded 10x the STLC value, and lead in LT-02 exceeded the TCLP value. In general, testing indicated that hazardous waste based on bulk concentration was not found to be present in any of the samples and disposal at a Class I landfill[2] will not be required. However, a more comprehensive sampling and testing program must be implemented to conclusively apply that assumption to the entire potential dredging volume (Section 2.2.2). Additionally, due to the elevated findings of

[2] Landfill authorized to accept hazardous waste under the Resource Conservation and Recovery Act (RCRA Subtitle C landfill).

chromium and lead, it is anticipated that leachate testing will be required prior to landfill acceptance of the dredged sediment.

Table 2-5
Summary of Total Threshold Limit Concentration, Soluble Threshold Limit Concentration, and Toxicity Characteristic Leaching Procedure Exceedances for Landfill Disposal

	LT-01			LT-02			LT-03		
Element	**TTLC**	**10x STLC**	**20x TCLP**	**TTLC**	**10x STLC**	**20x TCLP**	**TTLC**	**10x STLC**	**20x TCLP**
Chromium		X							
Lead		X			X	X		X	

2.2.3 Routine Site Maintenance

Dredging is not used as a routine maintenance method for Lake Temescal due to the high cost and challenging logistical obstacles. Instead, EBRPD manages current sediment influx to the lake by annually removing sediment from each of the three existing sediment basins located on the lower portions of Caldecott and Temescal Creeks. For this feasibility assessment, EBRPD provided sediment removal records from 2006 through 2018, which are discussed in more detail in Section 5.

During the winter season, EBRPD staff push sand up away from the shoreline to minimize erosion during storms. Sand is imported to refresh the beach as needed. Records since 2007 indicated that sand has been imported in 2007, 2014, 2016, 2017 and 2018, roughly coinciding with wetter years. Each import consisted of roughly 100 tons of sand (Miller 2018).

2.2.4 Water Quality

The water in Lake Temescal has been impacted by cyanobacteria for decades. Cyanobacteria, commonly known as blue-green algae, are naturally-occurring organisms found in freshwater streams, rivers, and lakes. It can produce high concentrations of toxins during blooms and are a common problem found in aging reservoirs and artificial lakes. Cyanobacteria are known to bloom under conditions of elevated nutrient loads, limited water circulation, and increased temperatures. The continued growth and decay of plant material further deprives the system of oxygen, which further supports cyanobacteria because it thrives in anoxic or near-anoxic conditions.

The most effective methods for combating the algae blooms are to remove the existing nutrient-laden sediment from the lake and eliminate the available phosphorus by increasing the water column depth, reducing direct nutrient loads from the Caldecott and Temescal tributaries, and encouraging oxygenation.

In collaboration with the Alameda County Environmental Health Department, EBRPD tests water samples from four locations at Lake Temescal for bacterial levels on a weekly basis from April to October. EBPRD also performed water quality monitoring of nutrient levels in 2017 and 2018 (Section 4.1). When acceptable lake water quality levels are not met, human contact with the lake is restricted in compliance with EBRPD's monitoring program and closure protocol. However, the water within Caldecott and Temescal creeks is not directly monitored or regulated (EBRPD 2018).

2.2.5 Observed Species

EBRPD stocks Lake Temescal with rainbow trout from fall through spring, and with channel catfish in the summer. EBRPD also promotes the reproduction and growth of the existing population of largemouth bass, bluegill, and sunfish (EBRPD 2018).

Various bird species have been observed in the Lake Temescal park, including ducks, sparrows, herons, and double-crested cormorants. The Golden Gate Audubon Society performs annual Oakland bird counts; however, limited information is available specifically for Lake Temescal. Based on historical bird counts, it is believed that over 130 species have been observed in or near the lake. (eBird 2018).

EBRPD staff have recorded observations of a river otter at the lake every year since 2014 (Miller 2018).

3 Restoration Options - Conceptual Design Requirements

A successful lake restoration project requires implementation of both problem control measures and preventative measures to repair and sustain improved water quality. Control measures include solutions such as dredging or excavation to remove sediment from the lake or trap sediment before it enters the lake. Preventative measures require a more detailed lake system analysis of the aquatic ecology.

The following three lake restoration options were identified for analysis in this feasibility assessment. If implemented in combination, they would provide both control and preventative measures:

- Dredging to achieve increased water depth within the lake and remove nutrient-laden sediment
- Creation of treatment wetlands at the creek inlets to remove nutrients from incoming flows prior to reaching the lake
- Expansion of existing sediment basins to increase capacity to collect incoming sediment before it reaches the lake

Figures 3-1 and 3-2 show a conceptual representation of the three restoration options in plan and section views, respectively.

Alex Horne, PhD, an expert on limnology, stated that the optimal dredging alternative for Lake Temescal would balance minimizing the dredging volume, while providing sufficient water depth to maintain a proper thermocline. A thermocline is a thin aqueous horizontal layer within a lake or large body of water, in which the most rapid temperature change occurs with depth. The thermocline divides the upper, warmer, and generally mixed layer called the epilimnion, with the deeper, colder, and generally calmer water called the hypolimnion. Using this approach, Dr. Horne identified 30 to 35 feet as the target water depth for Lake Temescal, which is anticipated to achieve a beneficial epilimnion-to-hypolimnion ratio volume of 3:1 or lower (Horne 2018).

An optimal dredging template would include a slightly sloped lake bottom that is generally void of holes or isolated pockets. The sideslopes would be as steep as possible without risking erosion or failure. Applying these parameters and assuming a top of sideslope at the shoreline, it was estimated that approximately 180,000 cubic yards would need to be dredged from the lake to achieve the target water depths.

The optimal wetland alternative would maximize the wetland surface area to allow proper residence time for inflow filtration, while minimizing impacts to existing open lake surface area. The justification for the treatment wetland design requirements are discussed in Section 4.2. It was estimated that two treatment wetlands could be created to maximize nutrient uptake: one at the Temescal Creek inlet sized at 40,000 square feet and one at the Caldecott Creek inlet sized at 20,000 square feet. This feasibility assessment assumes the wetlands could be constructed using dredged sediment and would use approximately 20,000 cubic yards and 10,000 cubic yards at each location, respectively.

The optimal sediment basin enhancement alternative would maximize sediment retention capacity to prevent as much sediment from entering the lake as possible, while minimizing impact to the surrounding park features such as walkways, open space, and parking. The sediment basin enhancement approach is described in Section 5.

The proposed upland laydown areas, or construction staging areas, are also shown in Figure 3-1. These laydown areas could be used for dredged sediment dewatering and stockpiling, and potentially for on-site upland reuse of sediment to raise existing grades.

4 Purpose and Feasibility of Treatment Wetlands

Treatment wetlands are a form of green infrastructure that are engineered and constructed to reduce nutrient inputs into a water body. Compared to natural wetland systems, treatment wetlands achieve a much higher removal of nitrogen, phosphorus, suspended solids, heavy metals, and other pollutants due to greater control of flow paths and hydraulic residence times. Using treatment wetlands at Lake Temescal may be an effective preventative measure to sustain improved water quality conditions after dredging.

4.1 Nutrient Loads

As discussed in Section 2.2.4, Lake Temescal has ongoing issues with algae and nuisance aquatic vegetation due to high nutrient levels in the water. Algal growth can be limited by decreasing available phosphorus and nitrogen to values associated with mesotrophic lakes (or lakes with moderate nutrient levels).

EBRPD performed water sampling in August of 2016 on tributary creeks around the lake, which indicated high total phosphorus concentrations at approximately 0.176 to 0.242 milligram per liter (mg/L), from the mouths of the Caldecott and Temescal Creeks, respectively (SePRO Research & Technology Campus 2016). Median results from sampling in 2017 and 2018 were lower (IEH 2017, 2018), presumably due to multiple alum treatments in 2016 and 2017.

Nitrogen measurements were taken on an approximately monthly basis between 2002 and 2006. Typically, no detectible values were found, with the occasional measurement up to 2 to 3 mg/L. Nitrogen measurements in 2017 and 2018 reflected nitrate concentrations typically below 0.5 mg/L, but occasionally as high as 1.1 mg/L.

Table 4-1 summarizes these results for comparison with target nutrient concentrations associated with mesotrophic lakes.

Table 4-1
Summary of Available Nutrient Data

Source (Date)	Location		Total Phosphorus (mg P/L)	Phosphate (mg P/L)	Nitrate (mg N/L)	Ammonia (mg N/L)
Friends of Temescal Creek (2002-2006)	Lake Temescal Inlet	Typical Range		0.0 – 0.6	0.0 – 2.0	<0.1 – 0.5
		Median		0.1	0.0	0.1
		Maximum		0.6	60.0	0.5
EBRPD (August 2016)	Mouth of Caldecott		0.176			
	Mouth of Temescal Creek		0.242			
	Other Locations		0.171 – 0.382			
EBRPD[1] (2017-2018)	Caldecott Outlet		0.049	0.029	0.43 (maximum 0.95)	
	Streamside		0.097	0.067	0.04 (maximum 1.1)	
	NW Dock Surface		0.076	0.048	0.03 (maximum 1.1)	
		Target[2]	<0.025	<0.03	<0.5	

1. Multiple alum treatments took place during this period which lowered phosphorus and phosphate concentrations. Reported values reflect the median values over the sampling period.
2. Target values reflect concentrations associated with mesotrophic lakes (EBRPD 2016, NEBF 2018, UMass 2018). No target was found for ammonia. However, if oxygenation and recirculation elements are incorporated in the final design, ammonia will not be a dominant form of nitrogen in the lake.

4.2 Development of Treatment Wetland Conceptual Design Requirements

Treatment wetland uptake rates for nitrogen and phosphorus vary considerably depending on temperature, season, hydraulic residence time, and plant species. The wetland treatment approaches for this project focus on Temescal and Caldecott creeks as the key sediment and nutrient sources to the lake. The steep hillslope to the west of the lake is believed to be only a minor source of sediment.

The primary treatment wetland would be located at the south end of the lake to capture flows from Temescal Creek. Typical dry-season flows in Temescal Creek are 0.08 to 0.15 cubic foot per second (cfs; Bauer et al. 2006). Flows in Caldecott Creek were observed to be much lower, which is reasonable given its smaller catchment area (flows are discussed further in Section 5). Based on this data, Dr. Horne recommended a treatment wetland hydraulic residence time of 2 to 7 days during low-flow conditions to achieve desired beneficial rates of nutrient removal from Temescal Creek. The estimated minimum surface area required to achieve a 2-day minimum residence time is approximately 20,000 square feet. To increase residence time to 7 days and maximize nutrient removal, the wetland would need to be enlarged to 40,000 square feet, thus reducing more of the open water of the lake (Horne 2018). Appendix C contains estimates of nutrient loading, hydraulic residence time, and nutrient removal calculations to support this recommendation.

As shown in Figure 3-2, the Temescal treatment wetland would include both a sediment trap for granular sediment settling and a shallow inundated and vegetated wetland area for settling of finer suspended particles and nutrient uptake. An earthen berm would separate and protect the wetland from any wave action from the lake. The earthen berm would be constructed out of dried and processed dredged sediment. The wetland sediment trap would be immediately downstream of the inlet and would receive flows with sediment that was not retained by the two upstream sediment basins. The wetland sediment trap would be approximately 5,000 square feet in area, with a depth of approximately 10 feet at the deepest point. It would require periodic excavation to maintain capacity, approximately every 2 to 3 years or more depending on the frequency and intensity of seasonal precipitation. The expansion of the sediment basins upstream of the lake would help extend the maintenance cycle, as discussed in Section 5. A storm overflow bypass could also be included in the design to allow large runoff events to flow directly from the sedimentation area into the lake; however, active site maintenance would still be expected after wet seasons with large storm events.

Natural vegetation within the wetland is expected to consist of cattails and bulrush, which provide efficient nutrient absorption. Little to no vegetation maintenance is required unless mowing is desired to preserve lake visibility from shore. The accumulation of organic matter within the wetland is part of the pollution removal process, and it is anticipated that maintenance to remove the matter would be needed every 20 to 40 years. The inflow and outflow pipes should be cleared seasonally.

As shown in Figure 3-1, the wetlands could be situated along the southwest and southeast shorelines to minimize impacts to the view from the south end of the lake. A fishing pier or piers could be installed over the wetlands to compensate for lost shoreline fishing access and provide educational opportunities to view the wetland up close.

4.3 Other Resource Benefits of Treatment Wetlands

In addition to water quality improvements, bulrush and cattails in a treatment wetland provide nesting habitat for birds, shelter for small or young fish, and habitat for amphibians. By trapping suspended solids, the treatment wetland would extend the life of the dredging project and protect the deep-water resource in the north end of the lake along with its associated benefits to fish. Improving habitat diversity and water quality would also benefit wildlife viewing opportunities around the lake. Additionally, fishing and swimming at Lake Temescal would benefit from improvements in water quality and habitat.

4.4 Recommended Treatment Wetland Alternatives

Based on the approach and considerations discussed above, the two recommended treatment wetland alternatives are shown in Table 4-2. It is recommended that both alternatives be implemented to address nutrient loads from both creeks.

Table 4-2
Treatment Wetland Alternatives

Treatment Wetland at Creek Inlet	Surface Area (square feet)	Volume of Fill to Construct (cubic yards)	Summer Nitrogen Removal Capacity[1] (mg per day)
Caldecott	20,000	10,000	1,500,000
Temescal	40,000	20,000	3,000,000

Note:

1. Values may reflect removal rates larger than expected loads. In practice, removal rates are influenced by nutrient concentration with diminishing returns as nutrient concentrations decrease. Removal of 100% of nitrogen or phosphorus is not practical. Appendix C includes more detail.

5 Assessment of Future Sedimentation into the Lake

This section outlines the methods used to estimate future sedimentation in the lake, and application of that estimate to determine the optimal enhancement size for the existing sediment basins.

5.1 Estimate of Lake Sedimentation Rates

To inform the future sedimentation rate estimation process, three methods of data collection and assessment were used. First, published information which contained pertinent measured sedimentation rates, previous dredging projects, and historical lake depths and volumes was gathered from multiple EIRs, USEPA reports, park maintenance records, and archived newspaper articles. Much of this information is summarized in Table 2-1. This data was reviewed for patterns or indications of general sedimentation rates. Second, regional regression and land-use-based calculations were used. Third, observations and measurements were made in the field and using satellite imagery. Assessment of the available data supported an estimate that annual inflow rates likely ranged between 5,000 and 10,000 cubic yards per year between approximately 1963 and 1978, and between 1,200 and 1,850 cubic yards per year from 1979 to the present.

Sedimentation rate estimates are summarized in Table 5-1.

Table 5-1
Sedimentation Rate Estimates

Method	Measured or Estimated Sedimentation Rate (cubic yards per year)	References
Measurements from 1963 Through 1978		
Rates, depth, volume information from multiple sources	5,000–10,000	EBRPD 1978; USEPA 1980; Norfleet 1998
Measurements from 1979 Through 2017		
Sediment pond maintenance history and field measurements	215–850	EBRPD 1993, 2017, 2018; Horizon 2018
Lake volume change, 1979–2017	1,000	EBRPD 1978; USEPA 1980; Anchor QEA 2017
Combined sedimentation rate based on sediment pond maintenance and lake volume change	1,215–1,850	
Other Estimates Not Based on Direct Measurements		
Land-use-based estimate	1,200	SFEI 2009
Regional regression estimate (flow-based method using Wildcat Creek as reference)	1,600	SFEI 2009
Estimated Current Annual Sedimentation Rate	**1,200–1,850**	

Sedimentation rates between 1963 and 1978 are assumed to be higher than present-day sedimentation rates because of the large-scale disruptions in the watershed, including highway construction and development. The watershed is now mostly built out, with land use dominated by single-family residences and green space. While landslides and other large erosion-related events still occur in the watershed, especially on steep slopes, potential sources of sediment are currently more stabilized than throughout much of the 1900s. The sedimentation rates from the earlier period (1963 through 1978) could be viewed as an upper-level boundary of high rates for future planning purposes in the event of a significant fire or other dramatic change in land use or land cover. Although climate change may impact future storm events, it is not possible to predict when or to what extent; therefore, that was not factored into sedimentation estimates.

5.2 Design Implications and Recommendations

Measurements and observations of the existing Temescal and Caldecott creek sediment basins indicate that they can capture more sediment than EBRPD is permitted to remove under current regulatory permit allowances. Table 5-2 shows approximate sediment storage volumes of the three sediment basins based on field measurements by Horizon and depth information provided by EBRPD. The Caldecott and Temescal South basins appear to capture sand to gravel-sized sediment, while the Temescal North basin captures finer sediment and more organic materials.

Table 5-2
Sediment Basin Storage Capacity Estimates and Maintenance History

Sediment Basin	Maximum Depth (feet)	Current Area (square feet)	Sediment Storage Capacity (approximate cubic yards)	Maximum Sediment Removal Permitted (cubic yards per year)	Average Sediment Removed 2006-2018[1] (cubic yards per year)	Average Sediment Removed 1981-1993[2] (cubic yards per year)
Caldecott	4	1,150	170	200	67	--
Temescal North	5	3,900	720	200	127	--
Temescal South	5	1,550	290	200	91	--
Total			**1,180**	**600**	**285[1]**	**750**

Note:
1. Sediment basin maintenance notes contained some uncertainty.
2. The volume removed from individual basins was not available in 1981 through 1993.

Estimated rates of current sediment load to the lake (1,200 to 1,850 cubic yards per year) are not only higher than the estimated total amount of sediment removed from the basins (285 cubic yards per year), but also higher than the total sediment storage capacity of the basins (1,180 cubic yards).

Therefore, it is recommended that EBRPD expand the size of the basins to expand sediment storage capacity.

Table 5-3 illustrates the potential storage capacity after expanding the creek sediment basins and creation of the treatment wetland sediment trap. The combined storage capacity of the proposed expanded creek basins and sediment trap (2,525 cubic yards) is greater than the likely average annual sedimentation load to the lake from Caldecott Creek and Temescal Creek (1,485 cubic yards per year, upper estimate in Table 5-3), which could help maintain the lifetime of the dredging project if the sediment basins are adequately maintained.

Table 5-3
Conceptual Storage Capacity of Expanded Sedimentation Basins

Sediment Basins or Treatment	Maximum Depth (feet)	Maximum Sediment Removal Permitted (cubic yards per year)	Sub-watershed Sedimentation Rate Estimate[1]	Current Sediment Storage Capacity (approximate cubic yards)	Sediment Storage Capacity with Enlarged Basins	Difference Between Enlarged Basin Capacity and Annual Sub-watershed Sediment Estimate[4]
Caldecott	4	200	350–460	170	230	-230
Temescal North	5	200	780–1,025	720	925	340 (1,270 including Lake Treatment Sedimentation Area)
Temescal South	5	200		290	440[2]	
Lake Treatment Sediment Trap	10	[3]		Not existent yet	930	
Total	**--**	**600**	**1,130–1,485**	**1,180**	**2,525**	**--**

Notes:

1. Based on San Francisco Estuary Institute land use and regional regression estimate methods (SFEI 2009)
2. Conceptual storage capacity based on widening of 15 feet
3. Will need to be part of new maintenance plan
4. Enlarged Basin Volume – Upper Sedimentation Rate Estimate. Negative values represent inadequate storage to capture annual sediment load. A positive value for one tributary does not offset a negative value in another because sediment enters the lake in different locations; therefore, no total value has been provided in this column.

Figures 5-1 through 5-3 illustrate the conceptual expansions at the Temescal North, Temescal South, and Caldecott Creek sediment basins, respectively, to maximize additional sediment storage while minimizing the impact on existing park resources.

Figure 5-4 illustrates an overview of the Lake Temescal watershed sediment transportation. Figures 5-5 and 5-6 illustrate the resulting influx from the watershed into Lake Temescal before and after recommended project restoration improvements are implemented, respectively.

5.3 Recommended Sediment Basin Expansion Alternatives

To maximize the lifetime of the lake dredging project, the following recommendations are made:

1. The lake maintenance plan and related permits should be updated to allow greater volumes of sediment removal from sediment basins. At a minimum, the plan should be updated to permit removal of the estimated maximum storage capacity indicated in Table 5-3.
2. While the Temescal Creek basins are the most important in terms of overall sediment contribution to the lake, particular consideration should be given to expanding and maintaining the Caldecott sedimentation basin because the estimated sediment delivery rate for the Caldecott Creek sub-watershed (350 to 460 cubic yards per year) exceeds the existing basin's sediment storage capacity (170 cubic yards) and its maximum permitted sediment removal amount (200 cubic yards).

Another approach was considered to potentially increase the frequency of sediment removal from the existing three basins along Temescal and Caldecott creeks to more than once per year. However, due to anticipated permitting and regulatory constraints, it is unlikely that sediment will be able to be removed from the three basins during the winter months. Therefore, this approach was not considered further.

6 Sediment Removal, Dewatering, and Placement

Dredging and dewatering logistics must be carefully evaluated at Lake Temescal due to the large dredging volumes and the moderately limited upland processing space. This section identifies and evaluates the most feasible sediment removal, treatment, and placement location alternatives. The applied production rates are conservative and are based on performance observations in similar site conditions. Actual production rates will be affected by physical grain size and can be optimized during the design phase.

The volume of sediment removed annually from the existing sediment basins is small compared to the potential lake dredging volumes; therefore, it is not included as part of this discussion.

6.1 Lake Dredging and Excavation Methods

Dredging in Lake Temescal can be accomplished via mechanical or hydraulic dredging methods, or potentially in the dry by mechanical excavation after draining the lake. Selection of a dredging method is typically determined by construction logistics such as design depths and volumes, site access, environmental quality of the dredged sediment and effluent water, and available upland laydown space for dredged sediment dewatering. Regulatory permit conditions, cost, and contractor equipment availability also play a major role in the decision. The size of the laydown area needed for dredged sediment dewatering will vary at Lake Temescal depending on the technologies that are used. If the material will be transported off site, the laydown area will also require space for stockpiling and trucking operations. The lake dredging and excavation methods considered for this feasibility assessment are described in the following sections.

6.1.1 Hydraulic Dredging

Hydraulic dredging involves removing sediment through a slurry and suction mechanism. A cutterhead at the end of the intake of the hydraulic dredge is used to loosen sediment in situ, and water intake is used to create a sediment slurry of approximately 85% water and 15% solids. The water-and-sediment slurry is pumped directly from the point of dredging to the laydown area, where it is then dewatered. The cutterhead and intake often swing in an arc to dredge an area, and the whole dredge is advanced to the next location using self-propulsion, a small powered boat, or via winches or anchors.

At Lake Temescal, a small hydraulic dredge, such as one with a discharge pipeline ranging from 6 to 12 inches (similar to that shown in Figure 6-1), would be best suited. A larger dredge might overwhelm the system with too high of a pumping rate, causing unmanageable water effluent at the laydown area. Dredges this size can typically pump approximately 10,000 feet without a booster pump. However, if the slurry is pumped to the north laydown area, a booster may be necessary to assist in achieving the approximate 40-foot increase in elevation. Dewatered sediment from the laydown are would be placed back into the lake to create the in-lake treatment wetlands, because the hydraulically placed sediment would be difficult to shape and grade.

A significant advantage of the hydraulic dredging method is that it can operate continuously and transport sediment directly to the laydown area without the need for scows or double handling; therefore, it is more time efficient than mechanical dredging. However, the primary disadvantage is the large volume of water effluent that requires management at the laydown area. Additionally, there can be regulatory restrictions on the use of hydraulic dredges due to the risk of fish entrainment. However, this could likely be mitigated because Lake Temescal is stocked with fish.

6.1.2 Mechanical Dredging

The most common type of mechanical dredging method is performed using a clamshell dredge or an excavator mounted on a shallow draft barge. Dredged sediment is excavated from the water body and usually loaded on a transport device, such as a scow or haul barge, or directly placed on the laydown area or temporary re-handling area if it is within reach of the dredge. If sediment is loaded onto a barge, it is transported and either placed in water at a designated deep location or removed from the scow and placed upland for dewatering.

At Lake Temescal, one or more small mechanical dredges could be assembled with modular floating pontoons, similar to that shown in Figure 6-2. When dredged sediment is being placed upland at the north or south laydown area, it would need to be double-handled by placing the sediment in a barge and pushing the barge to an offloading system. The offloading system could be an excavator or a hydraulic pump, and would likely require construction of a temporary pier to access the barge from shore. The offloading system would remove the sediment from the scow and transport it to the laydown area for dewatering. Some dewatered sediment could be placed back into the lake to create the treatment wetlands if the sediment is too wet immediately after dredging to be placed directly into the wetland area.

A significant advantage of mechanical dredging is that much less water management is involved as compared to hydraulic dredging. However, the primary disadvantage is that mechanical dredging is typically a slower operation than hydraulic dredging and, aside from water management, transporting the sediment from the point of dredging to the laydown area for dewatering is more logistically complicated.

6.1.3 Mechanical Excavation (with Lake Draining)

As an alternative to traditional dredging, Lake Temescal could be drained, and mechanical excavation equipment could potentially be driven on to the lake bed to remove sediment in the dry. An excavator would remove sediment and place it in trucks, which would then transport it to an on-site processing area for drying before it would be suitable to truck off site.

The benefits of mechanical excavation in the dry would be that draining the lake would allow visibility of the sediment and work progress, in addition to the significant reduction of runoff water management needs.

The disadvantage of this approach is primarily related to the lake bed conditions. The accumulated lake sediment is known to be at least 40 feet thick in some locations and will be extremely wet after draining is complete. Even if the sediment is allowed to dry after the lake is drained, the sediment would still be very weak and unstable. Hultgren-Tillis Geotechnical Engineers reviewed historical geotechnical data in the 1978 draft EIR and stated that, based on the available information, they did not believe the lake bed could support the weight of land-based equipment, event with the use of interlocking construction matting for stabilization (Hultgren-Tillis 2019).

6.2 Dewatering Methods

RWQCB typically restricts suspended sediment particle concentration in effluent discharges, so it is critical to provide adequate particle and water separation during dewatering. For mechanical dredging and excavation, dewatering may require a few days or weeks of working or disking. However, for hydraulic dredging, dewatering becomes an important and complicated process because if the dewatering operations cannot meet or exceed the production rate of the dredge, the dredge will have to stop operation until the dewatering process catches up.

Similar to selection of the dredging method, selection of a particular dewatering method is typically determined by construction logistics, such as the identified dredging method, dredge volume, site access, and available upland space for staging areas and dewatering sediment. Regulatory conditions, cost, and contractor equipment availability also play a major role in the selection. Potentially applicable dewatering methods are described in the following sections.

6.2.1 Addition of Amendments

If the dredged sediment is fine grained, the dewatering process can be enhanced by the addition of amendments to bind the sediment into flocs and increase the rate of settlement. Some amendments also act as a stabilization agent for some chemical constituents and can reduce leachability. Portland cement or lime are most often used as additives because they are readily available and have predictable reactive characteristics. Fly ash is also used as an additive, usually in conjunction with cement or lime to reduce the overall additive cost.

Application of amendments during the dewatering process requires an on-site pugmill, which is an enclosed unit used for mixing. Dredged sediment and additive would be simultaneously inserted into the pugmill for mixing, resulting in notably drier sediment. This system is best applied to mechanically dredged or excavated sediment but could be used as a supplementary dewatering method for hydraulically dredged sediment slurry. Amendments are typically used to supplement other dewatering methods.

6.2.2 Settling Pond Dewatering

If sediment is mechanically dredged or excavated, and placed upland for dewatering, it could be placed in a containment pond made of plastic liner supported by K-rails (modular concrete barriers). The effluent water would be directed to flow through filters, such as fabrics or hay bales, to remove suspended solids prior to draining back into the lake (Figure 6-3). The sediment may also require some working using land-based equipment after the initial effluent water drains.

However, if material is hydraulically dredged and placed upland for dewatering, the settling pond would require a much larger surface area to allow proper residence time for settlement of suspended particles and to manage the amount of water associated with hydraulic dredging slurry. The pond would be constructed with earthen berms and would include a weir system for releasing effluent (Figure 6-4).

The somewhat sandy sediment assumed to be in the central and southern part of the lake would settle relatively quickly, possibly within several days. However, the predominantly fine silts and clays assumed to be located in the norther part of the lake have a much slower settling rate and could require weeks or months to settle. In the absence of laboratory column settling tests, it is approximated that proper settling of the fine silts and clays would require at least 1 acre of settling pond area for every 5,000 cubic yards of sediment dredged, with containment berms between 5 and 8 feet tall.

The settling process could be enhanced by adding inert flocculants, which cause suspended solid particles to coagulate and settle more quickly due to increased density. The settling pond area could also include a cell system or internal berm feature to create a longer slurry travel distance, increasing residence time.

6.2.3 Geotextile Tube Dewatering

Geotextile tubes may also be used to dewater hydraulically dredged material. Geotextile tubes are constructed from high-strength, woven, permeable geotextiles, and can reach sizes of several hundred feet long by about 60 feet in circumference when filled (Figure 6-5). Dredged slurry is pumped directly upland into the tubes at the laydown area, and sediment is retained within the tubes while the water drains through the permeable walls. The tubes are stackable for space efficiency. If implemented properly, use of geotextile tubes can be cost effective and time efficient. The geotextile tube manufacturer typically determines tube sizes and stacking arrangements to fit specific project conditions.

To accommodate geotextile tubes, the laydown area would need to be leveled, contained by berms or K-rails, and covered with an impermeable membrane to contain and control the effluent seepage from the bags. The empty tubes would be unrolled in place with the access and vent ports on the top and the drainage valves at the bottom.

In most operations, a polymer additive is injected to the slurry prior to its entrance into the bag to promote flocculation of sediment particles and increase the rate of settlement. This addition would require a chemical treatment pump, tanks of polymer, and a pipe manifold to facilitate the polymer injection.

Aside from a crew member impacting the walls of the tube with a bat or stick to stimulate settlement, no active maintenance is required during the dewatering process. Stacking the tubes on one another to create pressure on the lower-layer tubes is another dewatering stimulant, as well as an effective conservation of laydown space. Dewatering of a filled geotextile tube is anticipated to take up to 1 month, although this can be longer depending on the climate and the composition of sediment. Once the bags have sufficiently dewatered, the sediment can be excavated and placed or disposed.

Depending on the sediment quality, the decanted water is often suitable to be returned to the native waterways without additional treatment. If additional decant water filtration is required, however, it could be routed to a treatment area and filtered through a system such as Baker tanks. Additionally, additives can be applied to fine-grain sediment to encourage dewatering, enhance chemical stabilization, and reduce leachability.

The key to successful use of geotextile tubes is a steady flow of solids content in the dredge slurry. Slurry could be accommodated at the full pumping rate of a 10-inch or 12-inch hydraulic dredge (up to 90 cubic yards per hour); however, any change in dredged sediment density or material makeup could require a slowdown in the process to adjust flocculants. A conservative daily dredging rate of approximately 300 cubic yards is an appropriate assumption for an 8- to 10-hour work day.

Although dewatering using geotextile tubes is more space efficient than settling ponds, the upper and lower laydown areas cannot accommodate the required project dredging volumes in one dewatering phase. The likely dewatering plan using geotextile tubes would include multiple dewatering phases to rotate between the upper and lower laydown areas in a manner to minimize, but possibly not completely avoid, stopping of the dredge. Table 6-1 shows the approximate volume of in situ dredged material that could be dewatering per laydown area and the approximate duration to fill. The arrangement of geotextile tubes at the laydown areas can be optimized through coordination with vendors during the design phase of the project.

Table 6-1
Conceptual Dredging and Geotextile Tube Dewatering

Laydown Area	Approximate Size (acres)	Approximate In Situ Volume Dewatering Capacity (cubic yards)	Dredging Days to Fill Capacity	Estimated Days for Dewatering[1]	Estimated Days to Remove Dried Sediment and Prepare Site for Next Slurry Input[2]
Lower	2	4,000 to 6,000	13 to 20	30	10 to 15
Upper	4	10,000 to 14,000	33 to 47	30	25 to 35

Notes:
1. Dewatering of lake sediment is anticipated to take approximately 1 month, based on data from similar projects. However, actual drying times may vary due to composition of sediment within the tube (for example, sandy versus fine).
2. These durations assume that 500 cubic yards can be hauled off per day (approximately 3 to 4 trucks per hour).

Another benefit of geotextile tubes is that they can be used to form a containment barrier within the lake to backfill for wetland creation. The tubes would be lowered into the lake in a steel frame and filled in place. Several poles may need to be installed to prevent the tube from rolling into the deeper portions of the lake. Once placed and backfilled, the tubes would not require ongoing maintenance.

6.2.4 Rapid Dewatering System

Dewatering can be accomplished using a portable rapid dewatering system (RDS) during hydraulic dredging activities by pumping the sediment slurry directly into the RDS. If the lake is mechanically dredged or excavated, the dredged sediment would be manually fed to the RDS. The system typically consists of debris removal, coarse-grain separation by hydrocyclone or centrifuges, and separation of fine sediments by polymer flocculation or other methods (Figure 6-6). The water is usually clarified to the extent that it can be released directly back into the native water body. The resulting sediment is usually sufficiently dried for immediate trucking; therefore, this system eliminates the need for additional active dewatering methods such as mechanical working, disking, settling, or geotextile tubes.

The dredging contractor will often rent and operate the RDS equipment themselves, especially in the case where a hydraulic dredge is physically connected to the RDS. It is estimated that, combined with a hydraulic dredge, this method could process up to approximately 1,000 cubic yards per day under optimal conditions. This rate includes an assumption of an 8- to 10-hour work day, and uniform grain size in the dredge slurry. However, given the nature and uncertainty of Lake Temescal sediments, it is appropriate to assume that the RDS would be able to process around 300 cubic yards of dredged sediment per shift. This production rate could increase pending additional data collected during the design phase of the project and through further coordination with RDS vendors to discuss specific project conditions.

The benefits of this system include the compact laydown area space requirements in comparison to settling ponds and geotextile tubes. A complete RDS only requires an upland staging area of about 1 acre, not including a stockpiling area for dried sediment. This dewatering method will likely be the least intrusive to lake visitors and allows a high probability that EBRPD will be able to keep the park partially open during construction. Finally, this system provides separation of sediment by grain size, allowing sand to be segregated from fines and routed to targeted beneficial uses.

A significant challenge to this system is the mobilization and calibration of the system modules, which could take up to 6 weeks. Even more challenging are the difficulties in maintaining a steady intake of solids content in the dredged slurry. Additional challenges may include ongoing maintenance and repairs to the system, depending on the site conditions and contractor experience with the equipment. This could lead to downtime for the dredge. Therefore, it is recommended that the selected contractor has experience operating a similar system if rapid dewatering is preferred or required on this project. If dredging is performed over multiple events, it is recommended that the system stay on site during the downtime, due to the expense and effort of mobilizations.

6.2.5 Mechanical Working or Disking

If sediment removal occurs using mechanical dredging or land-based construction equipment, it may require working (spreading and drying by dozers) or disking (rotating and drying by harrowing disks). This would limit the thickness of the dredged material at the laydown area to just a few feet thick at a time to allow for effective drying. Using this method, mechanically dredged or excavated sediment could be dry within days during warmer weather, or within weeks or months if dewatering is attempted during rainy weather.

Mechanical working or disking alone is not sufficient to dewater hydraulically dredged sediment slurry, but could be implemented after another more aggressive dewatering method is performed.

6.3 Sediment Placement Opportunities and Logistics

A primary goal for evaluating dredged sediment placement opportunities is to beneficially reuse the sediment to avoid the logistical and cost impacts from transporting tipping fees. The alternatives for sediment placement for this project include the following:

- On-site treatment wetland creation
- On-site upland reuse as fill
- Off-site reuse
- Off-site landfill facility disposal

6.3.1 On-site Treatment Wetland Creation

A key feature of the Lake Temescal restoration is the option to create treatment wetlands to act as a filter in nutrient absorption before sediment and water enter the lake water. It is assumed that a portion of the dredged sediment could be reused on site to build up the recommended wetland areas. The proposed design requirements for the treatment wetlands are found in Section 4.2.

The wetland can be created by constructing an in-water containment berm, either with dewatered dredged sediment, or potentially filling a geotextile tube to serve as a retaining structure. Sediment would be backfilled to create the wetland, and after preliminary settling of the sediment, it could be shaped to meet the target grades. Alternatively, depending on the sediment quality in the adjacent areas, dredged sediment could potentially be mechanically placed over the berm by mechanical dredging equipment, or even hydraulically pumped and allowed to drain if the sediment has a high sand content.

6.3.2 On-site Upland Reuse as Fill

The dredged sediment that is not reused to create treatment wetland could be processed and placed upland at the project site for site grading of open space or parking lots. Strategically increasing some elevations may improve lakeview access, particularly if views are somewhat impacted along the southern portion of the lake after creation of treatment wetlands. Table 6-2 summarizes the potential upland fill uses at the site. Each potential on-site placement location is the same as the previously identified laydown areas. Therefore, a separate stockpiling area would have to be identified between dewatering and placing as fill.

Table 6-2
On-site Reuse Capacity

On-site Location	Dredged Volume Capacity to Raise Elevation
Upper Laydown Areas (combined parking lot and open grass areas)	6,400 cubic yards per 1 foot of elevation
Lower Laydown Areas (combined parking lot and open grass areas)	3,200 cubic yards per 1 foot of elevation

6.3.3 Off-site Reuse or Stockpiling

After dewatering, sediment could be transported to other EBRPD parks or other sites willing to accept material for beneficial reuse or stockpiling. It is anticipated that these sites would use the sediment for backfill or grading operations; therefore, there would be no tipping fee.

EBRPD identified two viable off-site park projects that may be able to accept dredged sediment from Lake Temescal for use as fill: the Tidewater Boating Center at the Martin Luther King, Jr. Regional Shoreline, which can accept 18,900 cubic yards per the 30% design plans; and the Point Isabel Regional Shoreline, which can accept an estimated 20,000 cubic yards. As noted, dredging volumes from Lake Temescal could be as high as 180,000 cubic yards, so a significant volume would still need to be placed at other locations (Goorjian and Gilchris 2018).

Another potential off-site opportunity that should be further investigated is the Dumbarton Quarry, a former mining and quarry site under reclamation for development as a new EBRPD campground and park. This site also may accept dredged sediment as part of the quarry pit backfill operation.

Additional off-site placement locations that warrant further investigation by EBRPD include the following:

- Pacific Gas and Electric Company (PG&E) parcels
- Local sport fields
- Claremont Country Club

6.3.4 Off-site Landfill Disposal

If there are no feasible on-site or off-site locations that could beneficially reuse or stockpile the dredged sediment, or if future sediment characterization indicates that it is not suitable for wetland cover or upland placement, it may need to be disposed of at a permitted landfill facility. Preliminary sediment characterization indicates that the dredged sediment would be suitable for a Class II or Class III landfill, which accepts putrescible (decayable) non-hazardous waste. If further sediment characterization determines that some of the dredged sediment is hazardous waste, disposal at a Class I landfill would be required.

Table 6-3 summarizes Class II and Class III landfills in the greater Bay Area and is organized by distance from the site. Final acceptance and tipping fees would need to be negotiated based on the chemical composition and volume of disposed sediment. Tipping fees for Class II and III landfills vary and are in addition to trucking fees. It is assumed that the Ox Mountain Landfill would be selected as the favored disposal site for this project because it has the lowest tipping fee and is within relative distance of the closer, more expensive sites. Therefore, the order-of-magnitude costs in Section 7 will apply a landfill tipping fee of $56.

There are only three Class I hazardous waste landfills in California, all of which are over 200 miles south of the project site. However, based on the exploratory testing program, it is not anticipated that disposal at a Class I landfill will be required for this project.

Table 6-3
Region 2 Landfill and Disposal Site Information

Site	City	Distance from Site (miles)	Estimated Tipping Fee ($/cubic yard)[1]	Class[2,3]	Drilling Muds	Waste Water Sludge	Soils with Petroleum	Composite Lined Cells
Quarry								
Dumbarton Quarry	Fremont	30	--	--	--	--	--	--
Landfills								
Keller Canyon[4]	Pittsburg	25	Call for pricing	II	X	X	X	X
Newby Island	Milpitas	37	$79	III		X	X	X
Redwood	Novato	38	$84	III	X	X	X	
Vasco Road	Livermore	40	$99	III	X	X	X	X
Zanker Road	San Jose	42	$140	III				X
Ox Mountain	Half Moon Bay	45	$56	III		X	X	X
Potrero Hills	Suisun City	47	Call for pricing	III	X	X		X
Guadalupe	San Jose	57	$52 to $135	III			X	X
Kirby Canyon	Morgan Hill	62	$48 to $136	III		X	X	X
Clover Flat	Calistoga	75	$44 to $116	III				X

Notes:

1. Tipping fees are estimated using information from site managers, however actual costs at time of construction may vary depending on volume disposed, sediment quality, or other factors. Tipping fee has been converted from a cost per ton, using the conversion of 1.6 ton per cubic yard.
2. Class II landfills accept only solid non-hazardous waste.
3. Class III landfills accept only solid non-hazardous "inert waste."
4. Keller Canyon is closed to the public.

6.4 Screening Evaluation and Recommended Restoration Alternatives

The following section provides a high-level screening evaluation to determine which dredging and dewatering methods and which sediment placement sites are the most feasible for the Lake Temescal restoration project. The most feasible alternatives from this evaluation are recommended alternatives, and order-of-magnitude costs are provided in Section 7. This evaluation can also be used to support eventual preliminary design and pursuit of California Environmental Quality Act (CEQA) approvals and regulatory permits.

6.4.1 Dredging and Dewatering Method Screening Evaluation

Assessment of dredging and dewatering methods includes consideration of logistical feasibility during mobilization and dredging operations. Mobilization includes transporting the equipment to the site and preparing both the dredging site and sediment processing site or sites. Dredging operations includes operational feasibility, production rate, and assessment of known operational challenges. The three dredging and excavation methods are assessed as follows:

6.4.1.1 Hydraulic Dredging

- Mobilization of dredging equipment and pipeline are feasible because all equipment can be brought in on flatbed trucks. The dredge pipeline would need to be assembled on site. Processing site preparation for a settling pond would require grading and building containment berms. Processing site preparation for geotextiles and RDS would require clearing the staging area or areas and potentially placing a ground liner for geotextile tubes. The RDS may take 6 weeks to initially calibrate.
- Operations require crew at two locations: the dredge and the dewatering site. Production rates are unknown using settling ponds; sand would settle quickly but silts and clays could remain in suspension for weeks or longer. Due to the limited space to build sufficient ponds, this dewatering alternative does not appear to be feasible.
- Production rates are estimated at 300 cubic yards per day with one dredge using either geotextile tube dewatering or rapid dewatering system; Duration of the project would be approximately 20 months for either dewatering system.
- Challenges with settling ponds include proper flocculation and settling of finer sediment to avoid slowing down the dredge and achieving proper effluent water clarity. Challenges with geotextile tubes include a potential slowdown during dewatering, and likely closure of the entire park to accommodate the tubes as they dewater. Challenges with a RDS include properly calibrating and maintaining a consistent solids content in the slurry.

6.4.1.2 Mechanical Dredging

- Mobilization of dredging equipment and offloading equipment and facility are feasible because all equipment can be brought in on flatbed trucks. Processing site preparation would require clearing space to work or disk sediment.
- Operations requires crew at three locations: the dredge, the rehandling site, and the dewatering site.
- Production rates are estimated at 200 cubic yards per day with one dredge. Duration of the project would be approximately 30 months if operated continually with one dredge.
- Challenges are relatively nominal.

6.4.1.3 Mechanical Excavation (with Lake Draining)

- Mobilization of equipment is feasible because all land-based equipment could be brought in on flatbed trucks. Processing site preparation would require clearing an area for working or disking. The dredging site would require draining of the lake and use of an extensive interlocking mat system for stability of equipment on the drained lake bed.
- Operations require crew at two locations: the excavation and the dewatering site. Additionally, trucks would be used to transport between the two locations. Equipment movement would be limited to areas where the stability mat is placed, thereby slowing production. Dewatering using sediment working or disking has nominal challenges, but dewatering with RDS
- Production could be up to 200 cubic yards per day but could be significantly slower due to mobility issues in the lake bed. Duration of the project would be approximately 30 months or for either dewatering system due to unknowns with the dredging rate.
- Challenges are significant due to the need to drain the lake and the geotechnical concern for the ability of the lake bed sediment to support the weight of the construction equipment and trucks. An additional concern is the potential odor caused by draining the lake.

The logistical feasibility and relative economic impact of each dredging and dewatering method is summarized in Table 6-4.

Table 6-4
Dredging Method Screening Evaluation

Dredging/ Excavation Method	Dewatering Method	Logistical Feasibility			
		Mobilization	Operations	Duration	Other Challenges
Hydraulic Dredging	Settling Ponds	Moderate	Difficult	-	Not feasible due to space
	Geotextile tubes	Feasible	Moderate	20 months	Full park closure
	RDS	Moderate	Moderate	20 months	RDS calibration
Mechanical Dredging	Working/ Disking	Feasible	Feasible	30 months	Nominal
Mechanical Excavation	Working/ Disking	Moderate	Difficult	30 months	Unstable soils; construction mats; odors
	RDS	Moderate	Difficult	30 months	Unstable soils; construction mats; RDS calibration; odors

Hydraulic dredging using settling ponds for dewatering is not recommended due to the lack of upland space to construct sufficiently sized dewatering ponds needed to properly clarify the effluent.

Mechanical excavation with lake dredging is also not recommended, regardless of the dewatering alternative used, due primarily to the concern over the lack of lake bed sediment strength to properly support construction equipment.

Therefore, the recommended dredging alternatives are hydraulic dredging using geotextile tubes for dewatering, hydraulic dredging using RDS to dewater, and mechanical dredging using working or disking for dewatering.

6.4.2 Sediment Placement Site Screening Evaluation

Assessment of the sediment placement site alternatives includes consideration of sediment suitability, placement site capacity, and logistical feasibility in transporting the sediment to the required location. The four placement site alternatives are assessed as follows:

6.4.2.1 On-site Treatment Wetland Creation

- Exploratory testing indicated that some of the sediment is likely suitable for treatment wetland creation. Due to some exceedances of PCBs, PAHs, and pesticides in the exploratory testing program, reuse of sediment from targeted areas of the lake may be required during engineering design. Final determination of material suitability would require additional sediment analysis, as discussed in Section 2.2.2.
- Wetland capacity can accommodate up to a total of approximately 30,000 cubic yards if both the Caldecott Creek and Temescal Creek wetlands are created.
- Creation of the wetlands is moderately feasible, but it would likely require removal of the sediment to dewater and dry before placing in the wetland area, to allow for proper shaping of the wetland features. Additionally, sediment may require strategic reuse to obtain the optimal sediment quality and grain size for construction.

6.4.2.2 On-site Upland Reuse as Fill

- Exploratory testing indicated that some or all the sediment is likely suitable for on-site upland placement. Due to some minor exceedances of arsenic, lead, dimethyl phthalate, and the PAH benzo(a)pyrene in the exploratory testing program, reuse of sediment from targeted areas of the lake may be required during engineering design. Final determination of material suitability would require additional sediment analysis, as discussed in Section 2.2.2.
- On-site reuse capacity can accommodate a maximum of approximately 30,000 cubic yards if the elevation of both the upper and lower parking lots and grass areas were raised by 3 feet.

- Construction of on-site reuse for raising existing grades is moderately feasible due to park closures. Additionally, the park would require a site plan and engineered upland design to address park modifications (e.g., to recreational access, existing features, and views).

6.4.2.3 Off-site Reuse

- Exploratory testing indicated that some or all the sediment is likely suitable for on-site upland placement. Due to some minor exceedances of arsenic, lead, dimethyl phthalate, and the PAH benzo(a)pyrene in the exploratory testing program, reuse of sediment from targeted areas of the lake may be required during engineering design depending on the identified final use. Final determination of material suitability would require additional sediment analysis, as discussed in Section 2.2.2
- Potential off-site reuse capacity exists at the Tidewater Boating Center and the Point Isabel Regional Shoreline of 18,900 cubic yards and 20,000 cubic respectively, for a total of 38,900 cubic yards. Additional opportunities may exist.
- Off-site reuse is feasible, assuming that the timeline of the Lake Temescal dredging project and the site accepting the material (if a construction project) are complimentary.

6.4.2.4 Off-site Landfill Facility Disposal

- Exploratory testing indicated that some or all the sediment is likely suitable for landfill disposal at Class II or Class III facility. However, due to the elevated findings of chromium and lead, it is anticipated that leachate testing will be required prior to landfill acceptance of the sediment.
- Landfill capacity is unlimited; however, disposal trucking and tipping fees are significant.
- Landfill disposal is feasible after the dredged sediment is dewatered so that no free water would drain from the truck bed.

The sediment suitability, capacity and logistical feasibility of each potential placement site alternative is summarized in Table 6-5.

Table 6-5
Sediment Placement Site Screening Evaluation

Placement Site	Sediment Suitability[1]	Site Capacity	Logistical Feasibility
On-site Treatment Wetland Creation	Some or all likely suitable	30,000 cubic yards	Moderate (multiple handling and strategic quality reuse)
On-site Reuse	Some or all likely suitable	30,000 cubic yards	Moderate (site closures and extensive planning)
Off-site Reuse	Some or all likely suitable	38,000 cubic yards identified potential capacity	Moderate (coordination)
Off-site Landfill	Some or all likely suitable (requires leachate testing to confirm)	Unlimited	Feasible

Note:
All sediment required additional testing prior to regulatory acceptance for placement site alternatives (Section 2.2.2).

All sediment placement sites alternatives are recommended because none have features associated with them that would create an extraordinary feasibility impact. However, due to the limited capacity of the treatment wetland, on-site reuse, and potentially off-site reuse, some off-site landfill placement will be required. Although feasible to implement, that is the most expensive alternative. On-site uses are limited; therefore, it is recommended that additional off-site reuse opportunities are further investigated.

7 Order-of-Magnitude Cost Estimates

7.1 Construction Costs

The construction costs presented in this section represent a conservative and reasonable approach regarding sediment removal and material disposal. All costs are presented in 2019 U.S. dollars. A 3.5% annual escalation rate can be applied to estimate future costs.

Order-of-magnitude costs are presented for the two recommended alternatives and include the following elements based on information presented in Section 6 of this feasibility assessment:

- Hydraulic dredging is recommended as the most feasible sediment removal technology and is included in alternatives 1 and 2.
- Geotextile tube dewatering and RDS technologies are included in alternatives 1 and 2, respectively, to highlight the cost difference associated with each technology.
- Mechanical dredging with mechanical working or disking dewatering is recommended as a secondary sediment removal technology, as it is feasible but has a 50% longer duration than hydraulic dredging.
- Wetland area creation and wetland sediment collection basin development are included in both alternatives to address long-term water quality considerations within the lake.
- Beneficial reuse of dredged material is included in both alternatives for creation of the wetland areas and on-site grading of material in the southern end of the park to raise elevations and maximize reuse of available materials.
- Off-site disposal (at a Class II or III landfill facility) is included in both alternatives because an alternate reuse facility or site has not yet been confirmed.

Key construction cost assumptions that are applicable to both alternatives are described as follows:

- Work will be completed using one dredge working one shift per day (10-hour shift) and 7 days per week to develop 300 cubic yards per day production rate (dredging and dewatering); production rates can be increased by working multiple shifts per day.
- The project will be completed as one construction effort (i.e., one mobilization and one demobilization) over an approximate 20-month continuous duration.
- Public access to Lake Temescal and parking and public areas will be completely restricted throughout most or all of the duration of the project using the geotextile tube dewatering alternative, and partially restricted throughout most or all of the duration of the project using the rapid dewatering and working and disking alternatives.
- The project contingency would address unanticipated costs, such as disproportionate increased in fuel rates at time of construction, moderate quantities of normal debris, disposal of a small portion of sediment at a Class I landfill, or treatment of discharge water.

Construction costs are presented in Tables 7-1, 7-2, and 7-3, and include a combination of lump sum and unit price cost elements. The costs represent a level of accuracy that is appropriate for a feasibility assessment of each alternative, and also includes an additional 25% construction contingency cost. A brief summary of each alternative is provided following the cost tables, and more detailed cost information (including statement of key assumptions associated with each construction item) is provided in Appendix D.

Table 7-1
Order-of-Magnitude Costs: Alternative 1, Hydraulic Dredge and Geotextile Tube Dewatering

Item No.	Activity	Unit	Quantity	Unit Rate	Estimated Cost
1	Mobilization/Demobilization	Lump Sum	1	$500,000	$500,000
2	Site Preparation (Upper and Lower Laydown Areas)	Lump Sum	1	$225,000	$225,000
3	Surveys	Lump Sum	1	$75,000	$75,000
4	Hydraulic Dredging	Cubic Yard	180,000	$18	$3,240,000
5	Dewatering (Geotextile Tubes)	Cubic Yard	180,000	$15	$2,700,000
6	Wetland Material Placement	Cubic Yard	30,000	$6	$180,000
7	Wetland Sediment Collection Area	Square Foot	5,000	$3	$15,000
8	On-Site Grading	Cubic Yard	30,000	$4	$120,000
9	Excess Material Trucking	Cubic Yard	120,000	$8	$960,000
10	Excess Material Disposal (Ox Mountain)	Cubic Yard	120,000	$56	$6,720,000
11	Sediment Basin Expansion (including sediment disposal at landfill)	Lump Sum	1	$300,000	$300,000
12	Oxygenation and Recirculation	Lump Sum	1	$100,000	$100,000
13	Site Restoration	Lump Sum	1	$1,000,000	$1,000,000
				Subtotal	***$16,135,000***
				Contingency (25%)	$4,034,000
				Total	**$20,169,000**

The hydraulic dredging and geotextile tube dewatering alternative assumes both the upper and lower laydown areas will be used to stage dewatering. Dredging operations will alternate filling geotextile tubes at one laydown area while the tubes at the other laydown area is allowed to dewater. There is an increased cost for site preparation and site restoration associated with this alternative due to need to disturb both laydown areas and potentially repave the parking areas. It is expected that the park will be completely closed with this alternative.

Table 7-2
Order-of-Magnitude Costs: Alternative 2, Hydraulic Dredge and Rapid Dewatering System

Item No.	Activity	Unit	Quantity	Unit Rate	Estimated Cost
1	Mobilization/Demobilization	Lump Sum	1	$650,000	$650,000
2	Site Preparation (Lower Laydown Areas)	Lump Sum	1	$175,000	$175,000
3	Surveys	Lump Sum	1	$75,000	$75,000
4	Hydraulic Dredging	Cubic Yard	180,000	$18	$3,240,000
5	Dewatering (Rapid Dewatering System)	Cubic Yard	180,000	$30	$5,400,000
6	Wetland Material Placement	Cubic Yard	30,000	$6	$180,000
7	Wetland Sediment Collection Area	Square Foot	5,000	$3	$15,000
8	On-Site Grading	Cubic Yard	30,000	$4	$120,000
9	Excess Material Trucking	Cubic Yard	120,000	$8	$960,000
10	Excess Material Disposal	Cubic Yard	120,000	$56	$6,720,000
11	Sediment Basin Expansion (including sediment disposal at landfill)	Lump Sum	1	$300,000	$300,000
12	Oxygenation and Recirculation	Lump Sum	1	$100,000	$100,000
13	Site Restoration	Lump Sum	1	$150,000	$150,000
				Subtotal	***$18,085,000***
				Contingency (25%)	$4,522,000
				Total	**$22,607,000**

The hydraulic dredging and RDS alternative assumes only the lower laydown area will be needed for dewatering and material stockpiling. There is an increased cost for mobilization and use of the RDS; however, site preparation and site restoration costs associated with this alternative are lower due to less disturbance of the laydown areas and the expectation that repaving the parking lots after construction can be avoided. Additionally, public access to the park will be more available if this alternative is implemented.

The mechanical dredging alternative assumes only the lower laydown area will be needed for dewatering and material stockpiling. There dewatering cost is lower for this alternative because the sediment has a much lower water content than that from hydraulic dredging. However, the dredging fee is much higher due to the need for double handling of the sediment (once by dredging and twice by unloading the scow). Additionally, this alternative is 50% slower than the hydraulic dredging alternatives, therefore includes higher overhead and profit costs. Public access to the park will be more available if this alternative is implemented.

Table 7-3
Order-of-Magnitude Costs: Alternative 3, Mechanical Dredge and Working and Disking Dewatering

Item No.	Activity	Unit	Quantity	Unit Rate	Estimated Cost
1	Mobilization/Demobilization	Lump Sum	1	$200,000	$200,000
2	Site Preparation (Lower Laydown Areas)	Lump Sum	1	$175,000	$175,000
3	Surveys	Lump Sum	1	$75,000	$75,000
4	Mechanical Dredging	Cubic Yard	180,000	$50	$9,000,000
5	Dewatering (Working / Disking)	Cubic Yard	180,000	$10	$1,800,000
6	Wetland Material Placement	Cubic Yard	30,000	$6	$180,000
7	Wetland Sediment Collection Area	Square Foot	5,000	$3	$15,000
8	On-Site Grading	Cubic Yard	30,000	$4	$120,000
9	Excess Material Trucking	Cubic Yard	120,000	$8	$960,000
10	Excess Material Disposal (Ox Mountain)	Cubic Yard	120,000	$56	$6,720,000
11	Sediment Basin Expansion (including sediment disposal at landfill)	Lump Sum	1	$300,000	$300,000
12	Oxygenation and Recirculation	Lump Sum	1	$100,000	$100,000
13	Site Restoration	Lump Sum	1	$150,000	$150,000
				Subtotal	***$19,795,000***
				Contingency (25%)	$4,949,000
				Construction Total	**$24,744,000**

It is important to note that a significant cost is included (for all three alternatives) regarding excess material disposal. It is recommended that additional optimization of the dredge prism be performed during the design phase of the project to reduce required dredging volume (if possible) so that overall project costs can be reduced. It is also recommended that EBRPD seek other potential sites where excess dredged material could be transported for reuse that would not charge a tipping fee. Diverting the remaining 120,000 cubic yards of dredged sediment from a landfill to a reuse facility could reduce overall project costs by up to $6 million.

7.2 Reporting, Regulatory, Design, and Construction Support Project Costs

In addition to the construction costs presented in Section 7.1, additional costs will be required for the project following selection of an alternative, including the following:

- Design, environmental, and biological data collection and evaluations
- Planning and project permitting
- Engineering design and bid support services
- Construction support services

These additional costs apply to both hydraulic dredging alternatives and are considered to be the same for each alternative presented and discussed above. Costs for each of these efforts are presented in Table 7-4. Additional cost assumption information is provided in Appendix D.

Table 7-4
Order-of-Magnitude Costs: Reporting, Regulatory, Design, and Construction Support

Item No.	Activity	Estimated Cost
Pre-Construction		
1	Sediment Characterization	$250,000
2	Geotechnical Evaluations	$200,000
2	Environmental and Technical Studies[1]	$150,000
3	California Environmental Quality Act[2]	$750,000
4	Permit Applications and Associated Reports[3]	$150,000
5	Post-Application Agency Coordination[4]	$75,000
6	Engineering Design and Bid Support Services[5]	$350,000
Construction and Post Construction		
7	Construction Support Services[6]	$690,000
8	Construction Environmental Compliance and Testing[7]	$50,000
	Total	**$2,665,000**

8 Earthen Dam Stability Assessment

A geotechnical evaluation was performed by Hultgren-Tillis Engineers (Appendix E) to assess whether dredging to the target elevations could impact the stability of the existing earthen dam at the northwest edge of the lake. The bottom of the dam would transition to the target dredging elevation by a sideslope of approximately 3 horizontal to 1 vertical. Within the dredging footprint near the dam, the dredging cuts would range from approximately 18 to 24 feet thick.

Based on the available information, the geotechnical evaluation concluded that dredging sediments to a depth of approximately 18 feet below the mudline would have no adverse impacts to dam stability if dredging is set back from the toe of the dam by 100 feet.

The geotechnical evaluation is included in Appendix D. It is recommended that this evaluation be revisited during engineering design when a final dredge prism has been developed to confirm dam stability and to assess potential surcharge loading in the upper laydown area associated with staging of geotextile tubes or the RDS for dredged material dewatering.

9 Regulatory Requirements

This section summarizes the anticipated regulatory requirements for the construction of the recommended restoration alternatives. Most of the regulatory requirements would be applicable regardless of the construction methods selected; however, site-specific sediment testing or permit conditions may also be required. It is recommended that EBRPD engage with the regulatory agencies early in the planning process to review the project and discuss key issues and approaches as a way to prevent (or reduce) potential project delays and associated increased costs due to a complicated and lengthy environmental review process.

9.1 California Environmental Quality Act

The California Environmental Quality Act (CEQA) requires that a public agency acting as the lead agency on a project in the state of California notify the public of potential environmental impacts from a proposed project through an official CEQA document. The type of document required depends on the size of the project, ability to mitigate environmental impacts, and discretion of the lead agency.

For this project, EBRPD could act as the lead agency for the CEQA process. Prior to initiating construction work, EBRPD would conduct an Initial Study (IS) to evaluate potential project impacts and determine the appropriate level of CEQA evaluation and documentation. A lead agency conducts an IS to determine whether a project may have a significant effect on the environment (CEQA Guidelines Section 156039[a]). If there is substantial evidence that a project may have a significant effect on the environment, an EIR would be prepared in accordance with CEQA Guidelines Section 15604(a). However, if the lead agency determines that revisions in the project plans or proposals mitigate the potentially significant effects to a less-than-significant level, a Mitigated Negative Declaration may be prepared instead of an EIR (CEQA Guidelines Section 15070[b]). In this case, the lead agency prepares a written statement describing the reasons a proposed project would not have a significant effect on the environment and, therefore, why an EIR is not the required document type for CEQA compliance.

For this feasibility report, a preliminary screening of CEQA Appendix G resource topics was conducted based on available site information. The results of this screening, including potential effects and benefits during construction and operations, are summarized in Table 9-1. Please note that this is not a formal CEQA evaluation, but rather an initial screening intended for planning purposes.

Table 9-1
CEQA Screening

CEQA Factor	Project Phase	Impact			Benefit	Notes
		Low	Medium	High		
Aesthetics	Construction	X	X			Temporary effects on views from dredging, treatment wetland construction, sediment stockpiles, and sediment basin expansions
	Operations	X			X	Views may be impacted by vegetation, cleaner water, and less algae
Agriculture Resources	Construction	X				
	Operations	X				
Air Quality	Construction	X				Emissions from construction equipment; odors from stockpiled sediments
	Operations				X	Odors from anoxic conditions in beach area should improve due to improved water quality and oxygenation
Biological Resources	Construction	X	X			Dredging and earthwork will disrupt wildlife and temporarily impact water quality in lake and downstream
	Operations	X			X	Maintenance of sedimentation basins may disturb wildlife, project will have overall benefit
Cultural Resources	Construction		X			Must consider excavation areas
	Operations					
Energy	Construction	X				New CEQA guidelines ask whether the project would result in wasteful, inefficient, or unnecessary consumption of energy
	Operations	X				
Geology/Soils	Construction					
	Operations					
Hazards and Hazardous Materials	Construction	X				Need to consider disposal of hazardous soils if present
	Operations					
Hydrology/ Water Quality	Construction	X	X			Dredging and earthwork will have temporary impacts on water quality in project area and potentially downstream
	Operations				X	Project will improve water quality in lake and downstream

CEQA Factor	Project Phase	Impact			Benefit	Notes
		Low	Medium	High		
Land Use/Planning	Construction	X				Must be consistent with City of Oakland General Plan
	Operations	X				Must be consistent with City of Oakland General Plan
Mineral Resources	Construction	X				
	Operations	X				
Noise	Construction	X				Construction equipment and activities
	Operations	X				Increased maintenance of sediment basins, oxygenation/recirculation equipment
Population/Housing	Construction	X				
	Operations	X				
Public Services	Construction					
	Operations					
Recreation	Construction	X				Temporary impact to park activities by construction
	Operations				X	Swimming, fishing, and wildlife viewing will benefit
Transportation	Construction	X				New CEQA guidelines require use of vehicle miles travelled (VMT) as standard evaluation approach
	Operations	X				
Utilities/Service Systems	Construction	X				
	Operations	X				
Wildfire	Construction	X				New CEQA guidelines require consideration of potential project effects to wildfire planning and response
	Operations	X				

9.2 Sediment Characterization Requirements

The San Francisco Bay RWQCB would be the primary agency to determine sediment suitability in relation to dredging methods and sediment placement locations, particularly if the sediment is placed as wetland or upland fill. Additional suitability restrictions might apply if the sediment is disposed of at a landfill, including leachate testing to predict the impact on ground and surface waters. The recent exploratory sediment analysis results (Anchor QEA 2018) would be used to assist in the development of a comprehensive plan to adequately characterize the maximum volume of sediment proposed in a dredging project. It is anticipated that a significantly higher number of cores would be required (at least 12) and that the cores would be required to extend to the maximum proposed dredging elevation.

If, through further testing, higher threshold exceedances are discovered, the sample cores could be tested in discrete intervals (instead of homogenized), to possibly determine whether there is an isolated lens of contamination within the substrate. Depending on agency coordination and laboratory findings, the ultimate testing program may require several subsequent testing phases until the agencies feel the sediment is properly characterized. The costs presented in Section 7 account for multiple rounds of testing, including testing of individual cores instead of testing a composite of multiple cores. Although there were some minor to moderate exceedances throughout the lake, the 2018 exploratory sediment testing indicated neither that the dredged sediment would be classified as hazardous waste nor that it would be excluded from the post-dredging placement sites for treatment wetland reuse, upland placement for fill, or landfill disposal.

9.3 Permit Requirements

The anticipated permit and regulatory compliance requirements for the proposed dredging are listed in Table 9-2. This table assumes that EBRPD owns the entirety of the project site.

Table 9-2
Permit and Regulatory Requirements

Regulatory Agency	Law/Regulation	Purpose	Permit/Authorization Type
U.S. Army Corps of Engineers, San Francisco District	Clean Water Act Section 404	Regulates placement of dredged and fill materials into waters of the United States	Individual Permit
San Francisco Bay RWQCB	Clean Water Act Section 401	Water quality certification for placement of materials into waters of the United States	Clean Water Act Section 401 Water Quality Certification
	Clean Water Act Section 402	National Pollutant Discharge Elimination System program regulates stormwater and construction discharges	National Pollutant Discharge Elimination System Construction Stormwater General Permit (requires preparation of a Stormwater Pollution Prevention Plan) for grading over 1 acre
	Porter-Cologne Water Quality Control Act	Regulates discharges of materials to land and protection of beneficial uses of waters of the state	Waste Discharge Requirements
California Department of Fish and Wildlife, Bay-Delta Region	Fish and Game Code Section 1600	Applies to activities that will substantially modify a river, stream, or lake; includes reasonable conditions necessary to protect those resources	Lake and Streambed Alteration Agreement (1602 permit)

Regulatory Agency	Law/Regulation	Purpose	Permit/Authorization Type
U.S. Fish and Wildlife Service	Endangered Species Act	The U.S. Army Corps of Engineers must consult with the U.S. Fish and Wildlife Service if threatened or endangered species may be affected	Concurrence Letter (informal consultation) or Biological Opinion (formal consultation)
State Historic Preservation Officer	National Historic Preservation Act Section 106	The U.S. Army Corps of Engineers must consult with the State Historic Preservation Officer if historic properties or prehistoric archaeological sites may be affected	State Historic Preservation Officer Consultation
City of Oakland	City Code	Grading would require a City Grading Permit	City Grading Permit
Bay Area Air Quality Management District	District's rules and regulations	Minimize particulate matter emissions	Authority to Construct (depending on new equipment installation types and quantities)

10 Additional Water Quality Treatment Options

The following treatment options can be considered to augment the lake water quality improvement and restoration effort:

- Oxygenation using microbubblers
- Circulation pipes along the lake periphery
- Beach management

Each of these treatment options would contribute to the sustainability of improved water quality. However, the proper conditions for improved and sustained water quality cannot be initially achieved without the implementation of dredging, treatment wetlands, and expansion of sediment basins.

A no-further-action treatment option, which would entail the continued use of alum treatments and vegetation removal, is also discussed in this section.

10.1 Oxygenation using Microbubblers

Enhancing oxygen levels in the lake would have multiple benefits in terms of water quality, habitat, nutrient removal, speeding the decay of biological material, and extending the life of the restoration project. Oxygenation of the lake water could be accomplished by mounting a microbubbler diffuser system at the bottom of the lake. This type of system releases air bubbles that promotes circulation of oxygen through the water column. Multiple designs exist, however, the most likely would require some on-site storage of oxygen and pumping equipment. Oxygen would be pumped through hoses that are secured in place but would not be anchored to the bottom of the lake to prevent burial.

10.2 Recirculation Piping

Similar to a microbubbler system, installation of recirculation piping pumping water from the lake through peripheral or treatment wetland areas would increase oxygen mixing within the lake and support additional nutrient removal. The park already has a shed with pumping and recirculation equipment south of the Beach House that could house oxygenation or recirculation equipment. To maximize benefits, the existing recirculation infrastructure would likely need to be upgraded to have a higher and more adjustable flow and to direct flows to treatment wetland areas.

10.3 Beach Management

The sand on the northeast beach was found to be highly contaminated with sulfides, which impacts recreational uses and wildlife habitat. These sulfides are present due to the historic anoxic conditions of the lake water and can react with available oxygen, contributing to current low-oxygen conditions. Replacement or cleaning of the sand, or dilution with non-sulfide contaminated sand, may reduce this additional contribution to the anoxic conditions. The oxygenation efforts discussed above would help improve beach conditions and prevent formation of new sulfides.

10.4 No Further Action (Continued Use of Alum Treatments and Vegetation Removal)

If no new lake restoration options were implemented, EBRPD would continue the existing alum treatment maintenance and vegetation harvesting program.

Alum works by binding with phosphorus in the water column and settling to the bottom of the waterbody. Under the right conditions, the phosphorus is buried in the sediment and its availability to the water column is suppressed. The effectiveness and longevity of alum treatments is decreased in shallow lakes and lakes with benthic feeding fish due to increased sediment and water column mixing. EBRPD's recent experience with alum additions has been successful in reducing algae, including toxic blue-green algae (cyanobacteria). However, using alum in current conditions can improve water clarity and boost growth of large filamentous algae (*Cladophora,* "blanket weed") which grows on the lake bottom where there is more phosphate and ammonia. Expansion of submergent-emergent weeds was observed over the shallow parts of the lake in recent years.

Alum treatment has proven successful; there were no closures in 2018 due to blue-green algae. However, alum treatment and vegetation removal without the implementation of additional restoration approaches would not reverse or slow the gradual filling-in of the lake. As the lake continues to fill in, the alum treatment maintenance would become less effective each year in managing blue-green algae growth, blanket weed growth would persist, and oxygen levels would continue to decrease, impacting fish and other aquatic species that occupy the lake.

11 Summary of Findings, Recommendations, and Next Steps

11.1 Summary of Findings

The findings summarized in this section are based on currently available information and are specific to the site assumptions included in this report. They may be modified if a significant assumption is adjusted, such as the use of upland laydown areas for sediment dewatering and sediment placement for grading. These findings are meant to assist EBRPD with determining a project scale to suit the recommended restoration outcomes, project budget, and timelines.

Table 11-1 summarizes conceptual design requirements to maximize restoration effectiveness.

Table 11-1
Summary of Dredging and Wetlands Conceptual Design Requirements

Element	Design Parameter
Target Water Column Depth	-30 feet to -35 feet
Dredging Elevation	391.6 feet to 396.6 feet NAVD88
Temescal Wetland Surface Area	40,000 square feet
Caldecott Wetland Surface Area	20,000 square feet

Table 11-2 summarizes the dredging volumes, maximum on-site reuse volume opportunities for both wetland creation and upland grading, and the remaining volume to be removed from the site if all on-site placement opportunities are used. Almost 130,000 cubic yards would need to be processed and trucked off site if lake dredging is performed to meet the maximum conceptual design requirements and all potential on-site reuse sites are used.

Table 11-2
Summary of Dredging and Wetlands Conceptual Volumes

Element	Volume (cubic yards)
Dredging Volume	180,000
Temescal Wetland Fill Volume	*20,000*
Caldecott Wetland Fill Volume	*10,000*
On-site Upland Grading (Upper)	*12,000*[a]
On-site Upland Grading (Lower)	*8,750*[a]
Remaining Dredged Volume	**129,250**

Note:

a. Assumes the parking area and both grasslands can be raised by a maximum of 5 feet.

11.2 Recommendations

Implementation of the Lake Temescal Restoration Plan includes selecting one or more restoration option to implement (dredging, treatment wetlands, and sediment basin expansion), then selecting the optimum alternative for each restoration option, or manner in which the restoration option will be conducted to increase the chances of success and efficiency.

11.2.1 Recommended Restoration Options

The recommended plan includes implementation of all three restoration options, which would combine dredging the lake, creation of treatment wetlands at the mouths of Caldecott Creek and Temescal Creek, and expanding the existing sediment basins. The installation of oxygenation and recirculation equipment would further enhance the restoration project and help sustain water quality into the future. These features would work together to maximize improvements to water quality and fish habitat while protecting the lifespan of the project. Dredging the lake to provide a 30- to 35-foot water depth with sideslopes as steep as possible without risking erosion or failure will create a beneficial epilimnion to hypolimnion ratio that will decrease sediment and water column mixing while improving cold water habitat for fish, as described in Section 3. The steeper slopes will minimize habitat for undesirable aquatic vegetation. Expanding sediment basins and removing larger volumes of sediment from them each year will slow sedimentation in the lake and decrease the flux of nutrients and other pollutants into the lake. The treatment wetlands will remove additional nutrients, suspended solids, and other pollutants from flows entering the lake. Oxygenation and recirculation equipment will remove additional nutrients and pollutants from water in the main body of the lake (present from winter flows or legacy pollutants entering water column from sediment). They will also improve fish habitat and suppress nutrients, hydrogen sulfide, and methylmercury.

Table 11-3 presents a detailed summary of the benefits, constraints, and costs of each lake restoration option, both when implemented individually and in combination.

Table 11-3
Summary of Lake Restoration Options

Restoration Options		Benefits	Limitations	Notes	Cost
Options Implemented Individually					
A	Alum Treatments (and Vegetation Harvesting)	– Low upfront costs – Settles nutrients and microalgae; Improves water clarity	– Temporary solution – Does not improve fish habitat – Cost will increase and eventually fail from infill	– Lake will continue to infill – Submerged vegetation thrives – Nutrients in sediment remain available to rooted, submerged aquatic vegetation – Sediment mixing will continue	$45,000 per year (increases as infill increases)
B	Dredging	– Adds depth and improves cold water habitat – Removes legacy nutrients and pollutants – Extends life of open water lake	– Does not stop sediment, nutrients, and pollutant inputs – Lake sedimentation will continue at current rate – Issues with algae likely to continue	– Lake will return to current volume in 100 to 200 years assuming no major sedimentation events (e.g., fires, earthquakes, or landslides).	$21.8MM to $26.5MM
C	Treatment Wetlands	– Removes nutrients and pollutants from inflow – Provides habitat	– Small/no hypolimnion – Wetlands would fill quickly with sediment	– Shallow depths and legacy nutrients would continue to fuel algal blooms and undesirable aquatic vegetation	$1.2MM
D	Sediment Basin Expansions	– Decreases sediment, nutrients and pollutants entering the lake	– Small/no hypolimnion – Partial reduction of nutrient load; Algae and poor quality persist	– Proportional increase in cost of maintaining larger basins	$300,000
E	Oxygenation and Recirculation	– Improves fish habitat – Raises dissolved oxygen – Removes biochemical oxygen demand and some nutrients – Suppresses nutrients, hydrogen sulfide, and methylmercury	– Nutrient removal impact of recirculation is limited without treatment wetlands – Does not address sediment, nutrients, and pollutant inputs to lake	– Issues with sedimentation, algal blooms, and nuisance aquatic vegetation will continue	$100,000

Restoration Options		Benefits	Limitations	Notes	Cost
Options in Implemented in Combination					
A + B	Alum Treatments + Lake Dredging	– Settles nutrients and microalgae; Improves water clarity – Adds depth and improves cold water habitat – Removes legacy nutrients and pollutants – Extends life of open water lake	– Does not stop sediment, nutrients, and pollutant inputs (besides phosphorus) – Lake sedimentation will continue at current rate – Issues with algae likely to continue	– Higher sediment off-haul costs than dredging options with treatment wetlands – Lake will return to current volume in 100 to 200 years assuming no major sedimentation events (e.g., fires, earthquakes, or landslides)	$21.8MM to $26.5MM
C + D	Treatment Wetlands + Sediment Basin Expansions	– Removes nutrients and pollutants from inflow – Provides habitat – Decreases sediment, nutrients and pollutants entering the lake (more than basin expansion alone)	– Small/no hypolimnion – Legacy nutrients and pollutants in may be mixed into water column	– Expanded basins decrease wetland maintenance needs to every 20 to 40 years – Proportional increase in cost of maintaining basins	$1.5MM
B + D	Dredging & Sediment Basin Expansions	– Adds depth and improves cold water habitat – Removes legacy nutrients and pollutants – Extends life of open water lake (more than dredging alone) – Decreases sediment, nutrients, and pollutants entering the lake	– Lake likely to continue to be eutrophic and have issues with algae – Issues with algae likely to continue	– Proportional increase in cost of maintaining basins due to removal of additional material – Continued maintenance of sediment basins will gradually decrease lake volume, barring major sedimentation events	$21.8MM to $26.5MM
B + C	Dredging & Treatment Wetlands	– Adds depth and improves cold water habitat – Removes legacy nutrients and pollutants – Extends life of open water lake – Removes nutrients and pollutants from inflow – Provides habitat	– Wetlands would fill quickly with sediment; then sediment, then nutrients, and pollutant inputs persist	– Treatment wetlands would need frequent maintenance to maintain designed residence times and nutrient removal rates	$19.7MM to $24.4MM

Restoration Options		Benefits	Limitations	Notes	Cost
A + B + D	Alum Treatments + Dredging + Sediment Basin Expansion	– Settles nutrients and microalgae; Improves water clarity – Adds depth and improves cold water habitat – Removes legacy nutrients and pollutants – Extends life of open water lake (more than with dredging alone) – Alum and increased depth limit growth of algae and nuisance aquatic vegetation	– Lower habitat value and pollution removal compared to options with treatment wetlands	– Proportional increase in cost of maintaining basins due to removal of additional material – With continued maintenance of sediment basins, lake volume will gradually decrease barring major sedimentation events	\$21.8MM to \$26.5MM
B + C + D	Dredging & Treatment Wetlands + Sediment Basin Expansion	– Adds depth and improves cold water habitat – Removes legacy nutrients and pollutants – Extends life of open water lake – Removes nutrients and pollutants from inflow – Provides habitat – Greatly decreases sediment, nutrients and pollutants entering the lake to extends life of the project (much more than dredging alone)	– No mechanism for removing nutrients in main body of lake (e.g., from animal waste and winter storm flows)	– Expanded basins decrease wetland maintenance needs to every 20 to 40 years and extend time to next dredging – Proportional increase in cost of maintaining larger basins	\$19.7MM to \$24.4MM
B + C + D + E	Dredging & Sediment Basin Expansion & Treatment Wetlands & Oxygenation and Recirculation	– This option has the greatest water quality and habitat benefits and slows the future decrease in lake volume more than other options – In addition to benefits above, this would offer additional improvements to water quality and fish habitat, including higher dissolved oxygen, increased nutrient removal, and suppression of nutrients, hydrogen sulfide, and methylmercury	– Most expensive to implement, including equipment maintenance costs	– Oxygenation and recirculation equipment would require maintenance – Expanded basins, treatment wetlands, and oxygenation would provide the greatest extension of the life of the dredging operation	\$19.7MM to \$24.4MM

11.2.2 Recommended Restoration Option Alternatives

The recommended alternatives for the treatment wetlands and sediment basin expansion consist of the conceptual design requirements, as set for in Sections 3 and 4. Construction of these options will be performed using standard land-based equipment.

The screening evaluation for dredging and dewatering resulted in the following recommended alternatives for consideration. All alternatives assume dredging the lake to a maximum water depth of 30 to 35 feet:

- Primary Recommendations
  - Dredging alternative: Hydraulic dredging
  - Dewatering alternatives: Geotextile tubes and rapid dewatering system
  - Placement alternatives: Combination of treatment wetland creation, on-site reuse for grading, off-site beneficial use, and landfill disposal to accommodate only the sediment that cannot be placed at a reuse opportunity
- Secondary Recommendations
  - Dredging alternative: Mechanical dredging (due to duration)
  - Dewatering alternatives: Working and disking

11.3 Next Steps

This feasibility report has identified three restoration options with associated construction assessment. To confirm viability of the restoration options and construction methods, and advance toward preliminary design, the following recommendations are provided:

1. Determine whether any aspect of a restoration project will be pursued, and if so, the approximate timeframe
2. Refine data
   a. Perform targeted data collections to supplement or verify existing data
      i. Develop and implement a program to measure flow data from Caldecott Creek
      ii. Enhance existing flow data from Temescal Creek[3]
      iii. Improve nutrient data collection program from Caldecott and Temescal Creeks, particularly phosphorous, and including collection from upstream locations[4]
   b. Rerun nutrient uptake calculations with new data to confirm size of the optimal treatment wetlands

[3] Per EBRPD, investigations are currently underway to enhance data collection from Temescal Creek.
[4] Per EBRPD, a sampling program is being developed to focus on upper watershed contributions.

3. Preliminary Design
    a. Identify extents and duration of acceptable impacts (closure of upland space, park access, recreational lake use)
    b. Review conceptual cost estimate and target a project cost range to help bound project parameters
    c. Dredging: Reevaluate based on acceptable impacts and costs and determine whether a reduced project could provide notable benefit to water quality (dredging to shallower depth or dredging only a portion of the lake)
    d. Wetlands: Apply targeted data to re-evaluate wetland requirements
    e. Sediment Basins: Apply targeted data to re-evaluate basin capacity expansion versus increased volume approvals
4. Sediment Characterization
    a. Once a preliminary dredging project is identified, coordinate with RWQCB and USEPA to prepare a comprehensive sediment testing program based on the investigative characterization provided in February 2018, including vertical stratification to potentially identify isolated contamination layers
    b. Engage RWQCB to determine suitability of sediment for wetland creation and upland reuse
    c. If landfill disposal is proposed, obtain individual acceptance criteria from the identified sites; anticipate leachate testing will be required due to elevated metals
5. Regulatory Approvals
    a. Engage with EBRPD staff to plan an IS to satisfy CEQA requirements and subsequently prepare the required CEQA document
    b. Engage RWQCB to determine monitoring requirements of the decant water returning to the lagoon
    c. Engage with RWQCB to prepare a permit application
6. Off-site Placement
    a. Investigate availability of other EBRPD sites for sediment acceptance.
    b. Investigate availability of other off-site locations for sediment acceptance, such as PG&E parcels, local sports fields, or the Claremont Golf Course
    c. If required, engage with the appropriate class landfills to confirm acceptance criteria and tipping fees (not anticipated from investigative characterization, but may be necessary if discrete contamination pockets exist within the lake).

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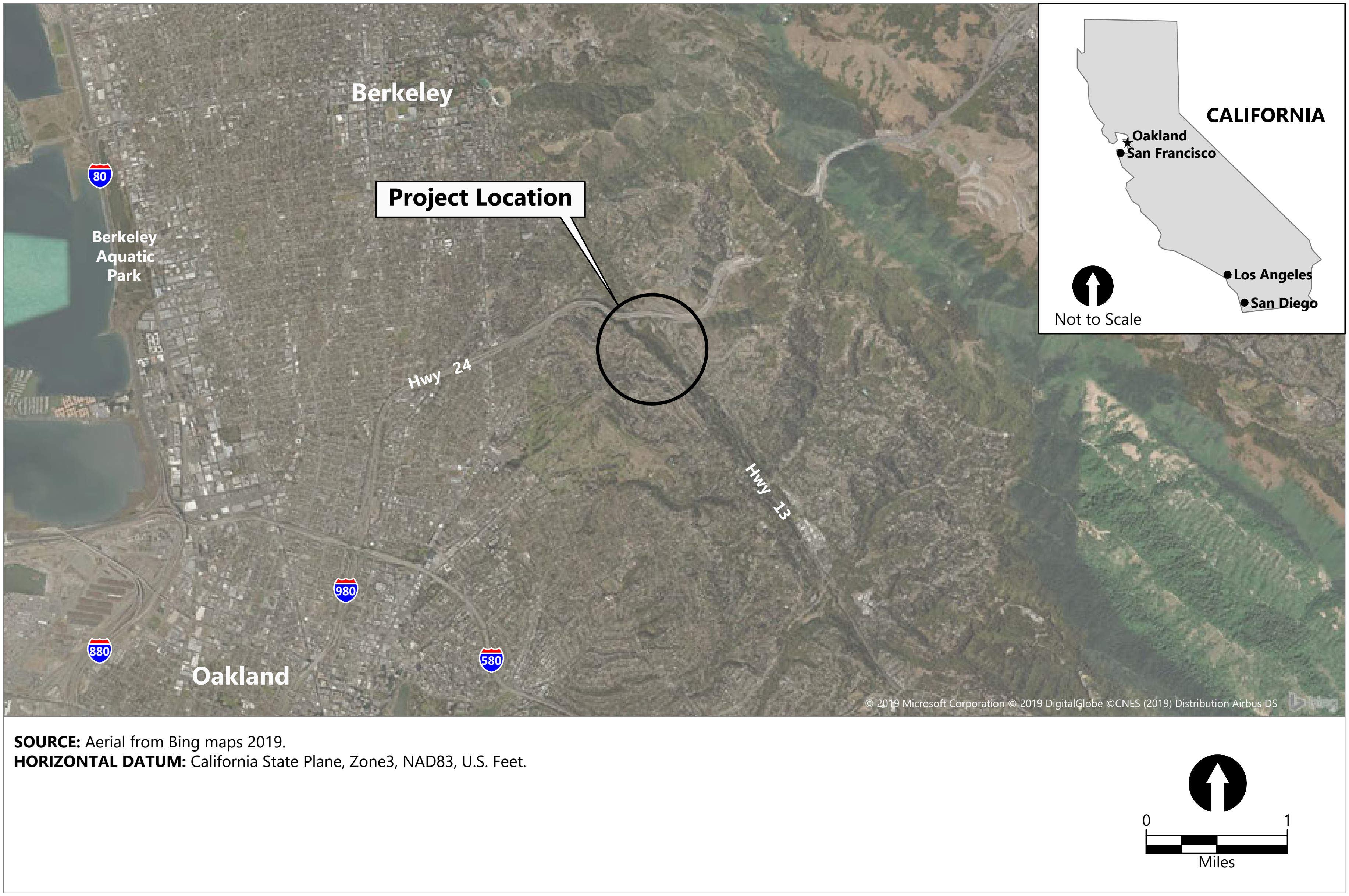
Figures



SOURCE: Aerial from Bing maps 2019.
HORIZONTAL DATUM: California State Plane, Zone3, NAD83, U.S. Feet.

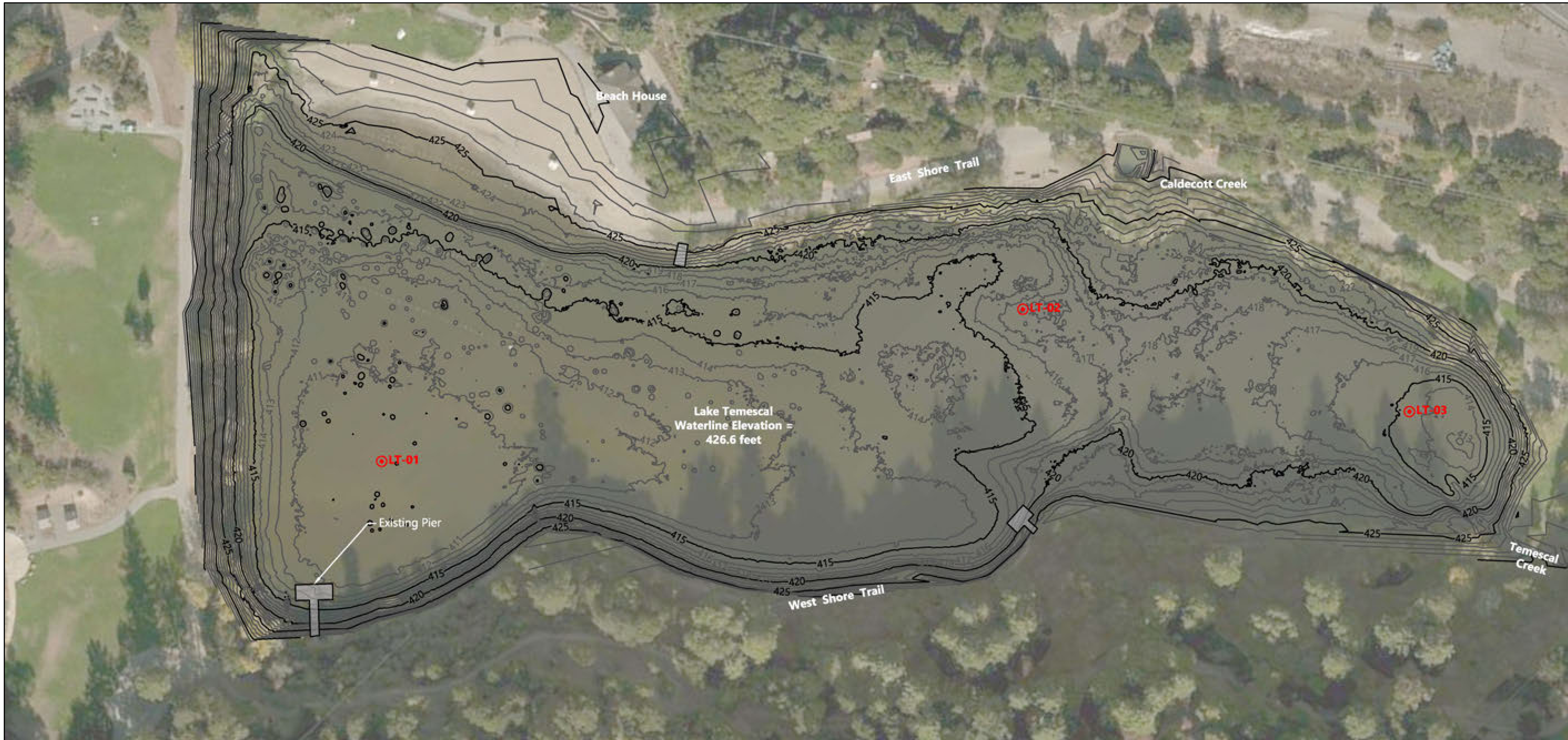
Publish Date: 2019/01/23 12:15 PM | User: rpetrie
Filepath: K:\Projects\1751-East Bay Regional Park District\Lake Temescal Dredging\1751 RP-001 VIC MAP.dwg Figure 2-1

ANCHOR QEA

Figure 2-1
Lake Temescal and Vicinity

Hydrographic and Bathymetric Surveying
Lake Temescal Dredging Feasibility Study

Figure 2-2
Investigative Sediment Analysis Sampling Stations



SOURCE: Aerial from Bing maps. Bathymetry from eTrac Inc., survey dated 2017.
HORIZONTAL DATUM: California State Plane, Zone 3, NAD83, U.S. Feet.
VERTICAL DATUM: NAVD88

LEGEND:

—420— Existing Contour (5 ft)

LT-# Actual Sampling Location

0 100 Feet

SOURCE: Aerial from Bing maps 2019.
HORIZONTAL DATUM: California State Plane, Zone3, NAD83, U.S. Feet.

NOTE:
1. All areas shown are approximate.

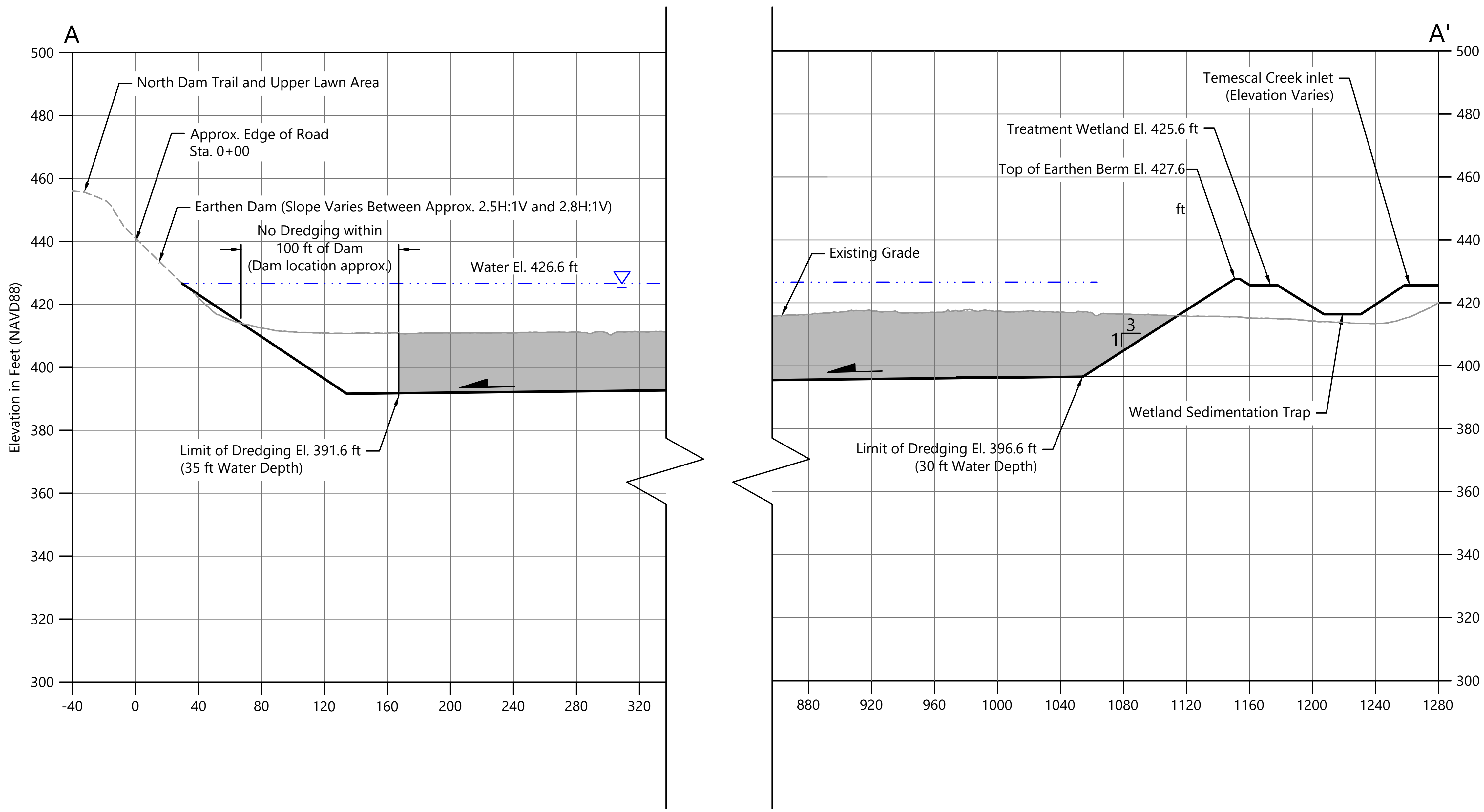
LEGEND:
- Dredging
- Treatment Wetland
- Laydown Area (Potential Onsite Upland Fill Sites)
- Sediment Basin

0 500
Feet

Publish Date: 2019/01/23 1:30 PM | User: rpetrie
Filepath: K:\Projects\1751-East Bay Regional Park District\Lake Temescal Dredging\1751 RP-005 RESTORATION OPTIONS.dwg Figure 3-1

ANCHOR QEA

Figure 3-1
Restoration Options Plan View
Hydrographic and Bathymetric Surveying
Lake Temescal Dredging Feasibility Study



LEGEND:

Water Elevation
Final Grade
Dredging (Excavation) Area
Slope
Wetland Alternative 2 Final Grade

NOTE: All elevations shown are North American Vertical Datum of 1988 (NAVD88)

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Filepath: K:\Projects\1751-East Bay Regional Park District\Lake Temescal Dredging\1751 RP-006 RESTORATION OPTIONS SECTION.dwg Figure 3-2

ANCHOR QEA

Figure 3-2
Restoration Section View

Hydrographic and Bathymetric Surveying
Lake Temescal Dredging Feasibility Study

Figure 5-1
Temescal North Sedimentation Basin Expansion Concept

Figure 5-2
Temescal North Sedimentation Basin Expansion Concept

Figure 5-3
Caldecott Sedimentation Basin Expansion Concept

Figure 5-4
Lake Temescal Watershed Sediment Transportation Overview

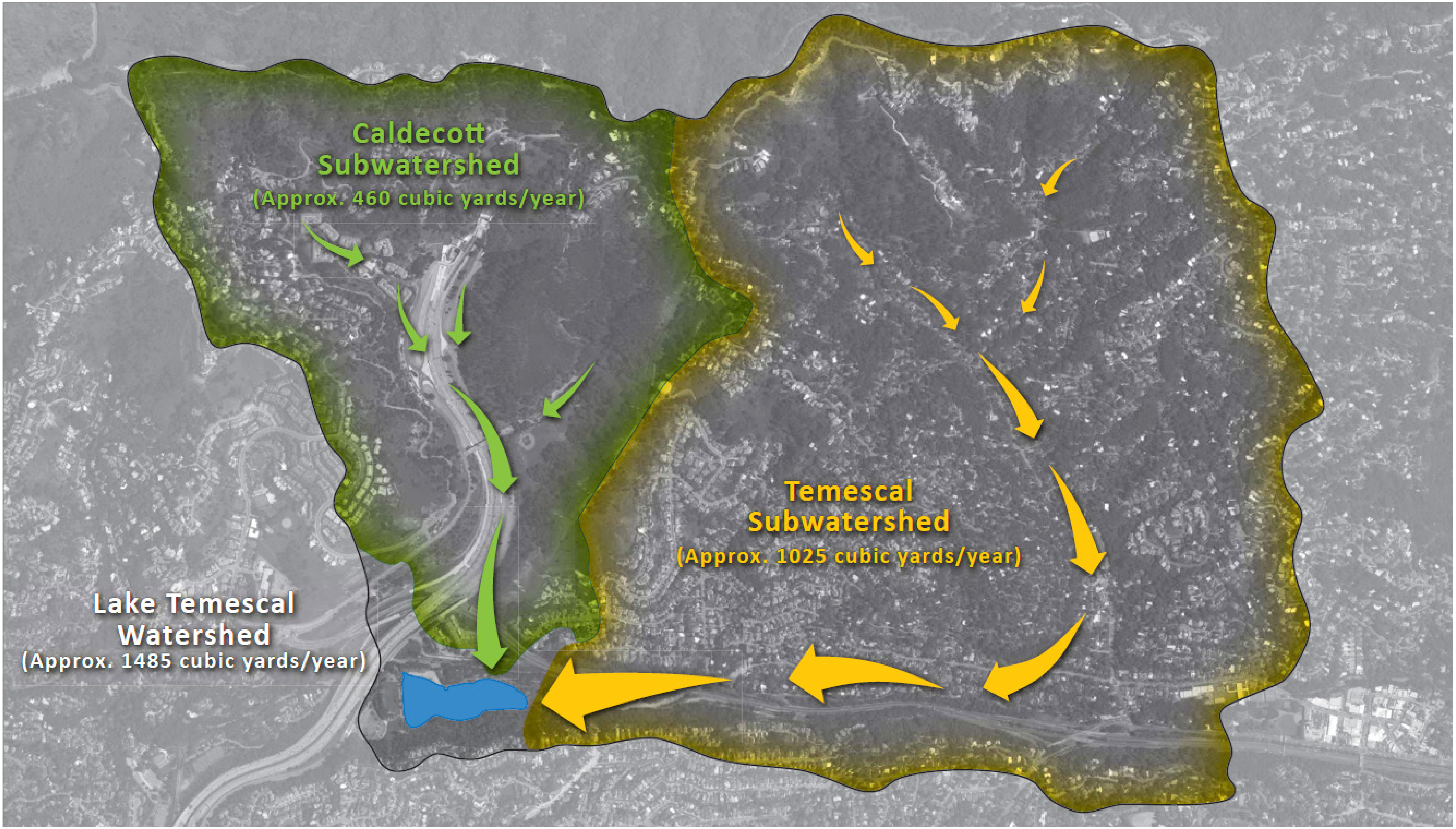


Figure 5-5
Lake Temescal Sediment Transportation – Existing

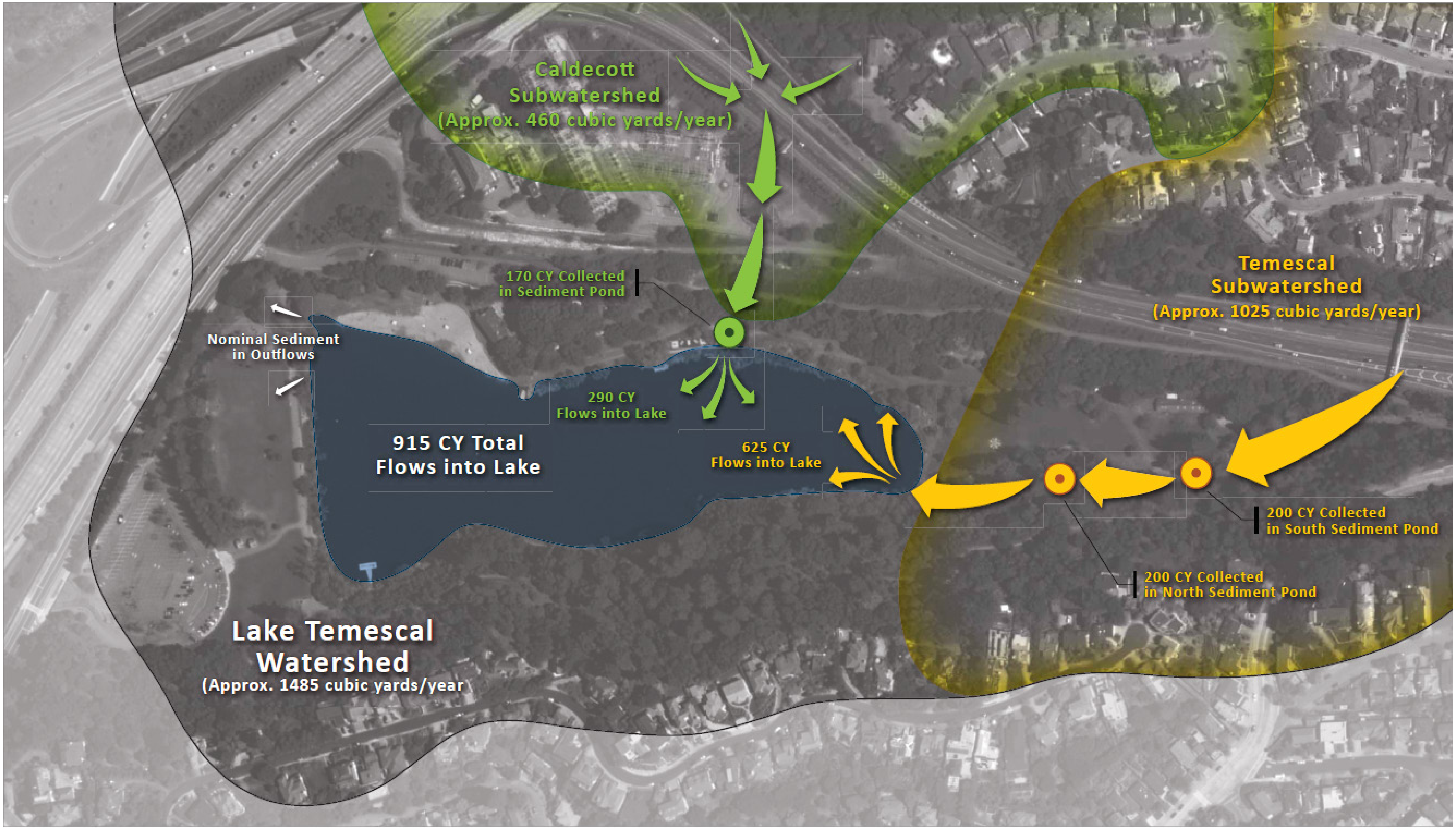


Figure 5-6
Lake Temescal Sediment Transportation – Following Improvements

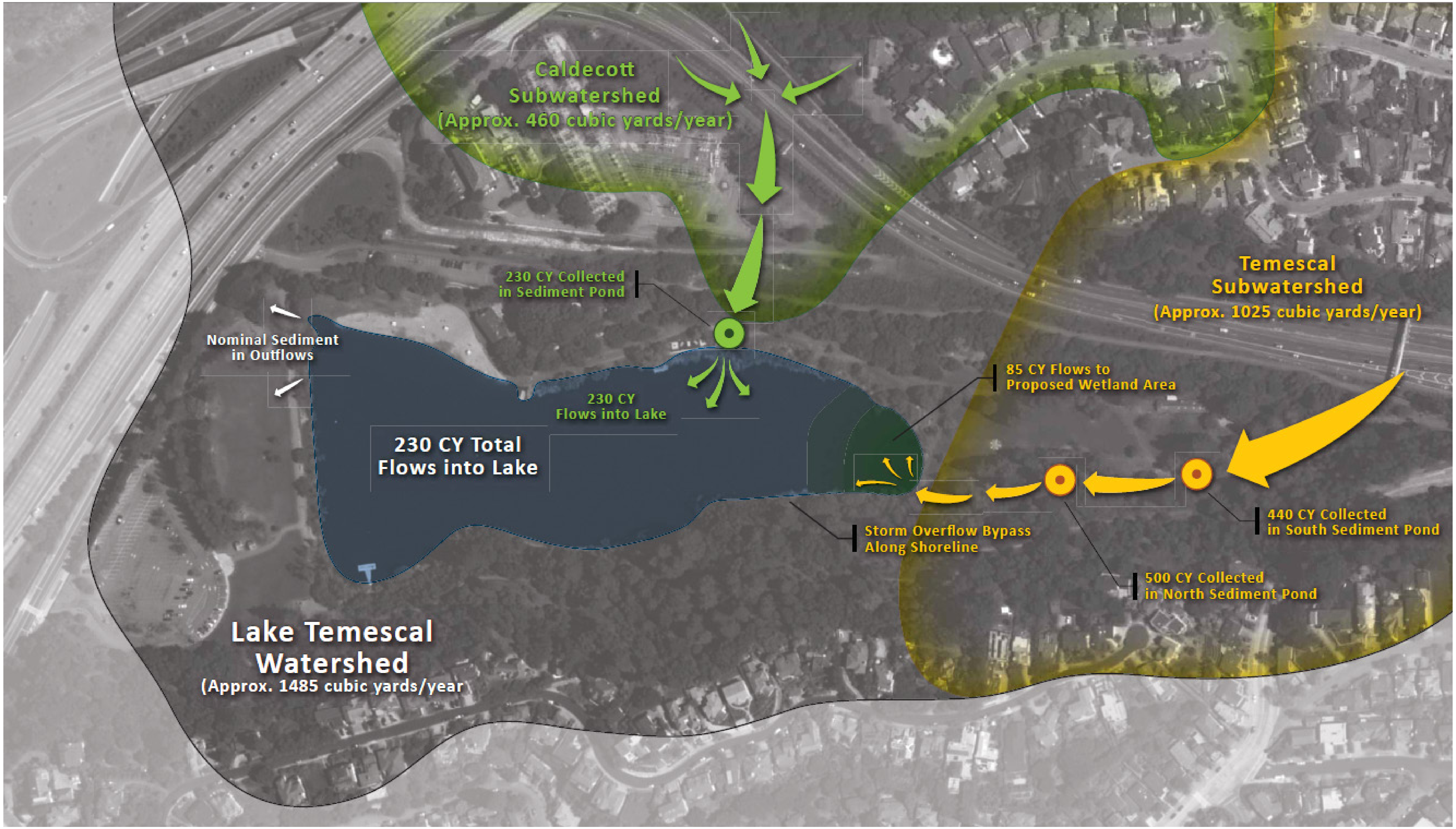


Figure 6-1
Small Cutterhead Hydraulic Dredge Equipment

Figure 6-2
Small Mechanical Dredge Equipment

Figure 6-3
Contained Dewatering (Mechanical Dredging)

Figure 6-4
Settling Pond Dewatering (Hydraulic Dredging)

Figure 6-5
Geotextile Tube Dewatering

Note: Top: releasing water; Bottom: stacking arrangement

Figure 6-6
Rapid Dewatering System

Appendix A
Lake Temescal Bathymetric Survey
(December 2017)

Lake Temescal

Multibeam Survey

GENERAL NOTES:

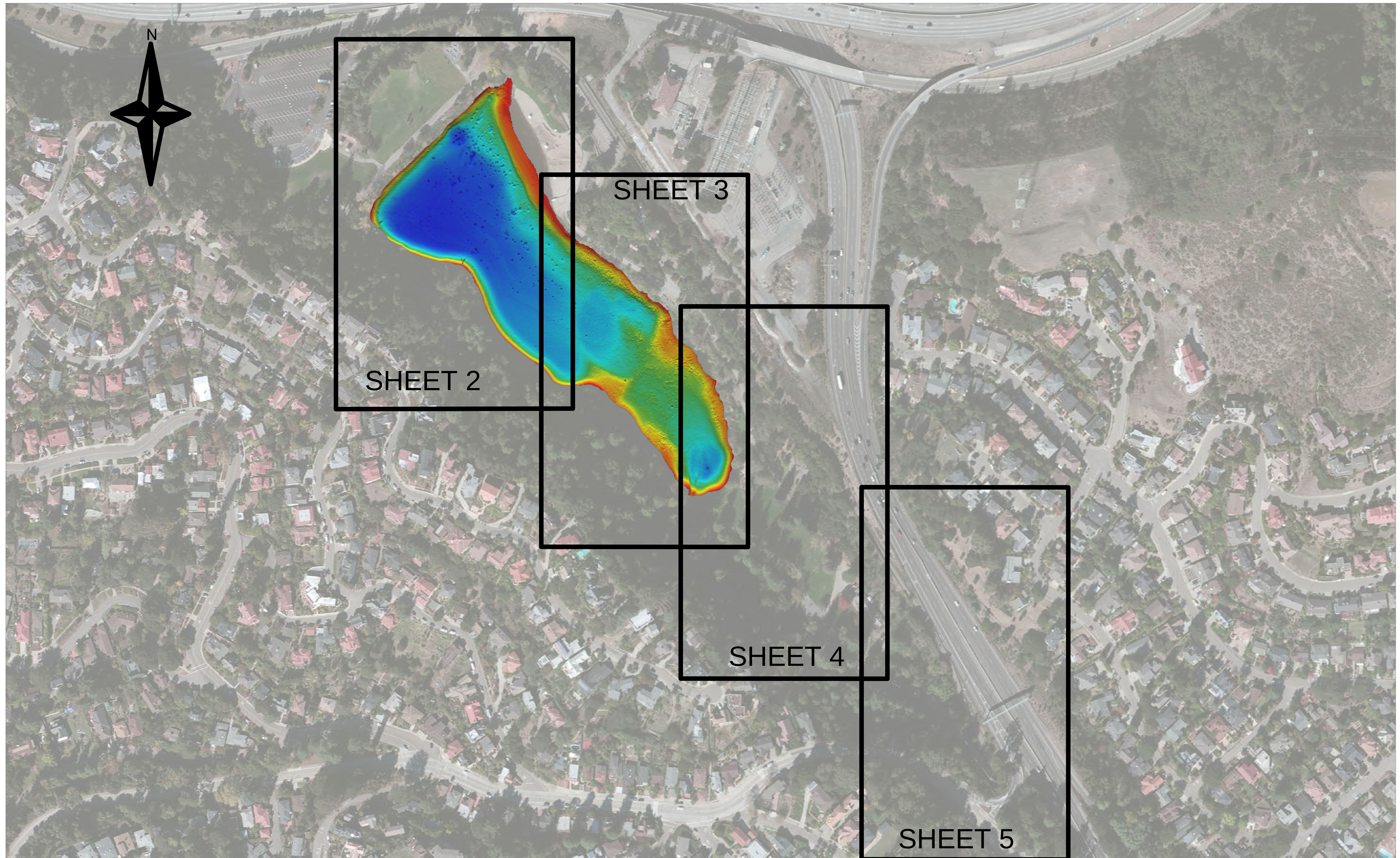
1. HORIZONTAL DATUM/PROJECTION: NAD83/SPCS CA ZONE 3 - US SURVEY FEET.
2. BATHYMETRIC DATA ACQUIRED BY ETRAC ON DECEMBER 19, 2017.
3. TOPOGRAPHIC DATA ACQUIRED BY ETRAC ON DECEMBER 19, 21 & 28.
4. VERTICAL DATUM: NAVD88 (US Survey Feet).
5. HORIZONTAL & VERTICAL CONTROL: EAST BAY REGIONAL PARKS BENCHMARK "2" LOCATED ON THE NORTH-WEST SIDE OF LAKE TEMESCAL; BENCHMARK "2" NORTHING: 2,135,757.64', EASTING: 6,061,684.48', ELEVATION: 441.66'.
6. POSITION AND MOTION DATA WERE COLLECTED USING AN APPLANIX WAVEMASTER V5 INS.
7. SOUNDINGS WERE COLLECTED USING AN R2SONIC 2020 MULTIBEAM SONAR.
8. BATHYMETRIC SOUNDINGS BASED ON 25FT SHOAL SORT.
9. TOPOGRAPHIC DATA COLLECTED WITH AN R8-1 ROVER USING RTK CORRECTIONS.
10. BATHYMETRIC INFORMATION REFLECTS THE CONDITIONS AT THE TIME IN WHICH THE SURVEY WAS CONDUCTED.
11. PHOTO ARROWS REPRESENT THE DIRECTION IN WHICH THE CAMERA WAS AIMING
12. GREEN ELEVATIONS ON PHOTOS ARE IN USFT FROM TOPOGRAPHIC DATA AND ARE ESTIMATED POSITIONS WITHIN THE IMAGE

SHEET INDEX:

Waterline Measurements

Date	Time	Elevation (USft)
December 21st 2017	11:20am	426.59
December 21st 2017	1:45pm	426.65
December 28th 2017	11:45am	426.66
December 28th 2017	3:45pm	426.60

Overview



not to scale

ANCHOR QEA
130 BATTERY STREET,
SUITE 400
SAN FRANCISCO, CA 94111
415.351.5151
ANCHORQEA.COM

eTrac
637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

PLOT DATE: JANUARY 12, 2018
DRAWN BY: NPJG | CHECKED BY: EM
CONTRACT #:
PERMIT #: EPISODE #:
PROJECT NAME:
ANCH_2017_Lake Temescal

Lake Temescal
Oakland, CA

Multibeam Survey

Reference Number:

S1

ANCHOR QEA
130 BATTERY STREET,
SUITE 400
SAN FRANCISCO, CA 94111
415.351.5151
ANCHORQEA.COM

eTrac
637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

PLOT DATE: JANUARY 12, 2018	
DRAWN BY: NPJG	CHECKED BY: EM
CONTRACT #:	
PERMIT #:	EPISODE #:
PROJECT NAME: ANCH_2017_Lake Temescal	

Lake Temescal
Oakland, CA

DTM, CONTOURS, SOUNDINGS & TOPOGRAPHIC SHOTS

Reference Number:

S2

ANCHOR QEA
130 BATTERY STREET, SUITE 400
SAN FRANCISCO, CA 94111
415.351.5151
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eTrac
637 LINDARO STREET
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PROJECT NAME:
ANCH_2017_Lake Temescal

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Oakland, CA

DTM, CONTOURS, SOUNDINGS & TOPOGRAPHIC SHOTS

Reference Number:
S3

ANCHOR QEA
130 BATTERY STREET,
SUITE 400
SAN FRANCISCO, CA 94111
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eTrac
637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

PLOT DATE: JANUARY 12, 2018
DRAWN BY: NPJG | CHECKED BY: EM
CONTRACT #:
PERMIT #: EPISODE #:
PROJECT NAME:
ANCH_2017_Lake Temescal

Lake Temescal
Oakland, CA

DTM, CONTOURS, SOUNDINGS & TOPOGRAPHIC SHOTS

Reference Number:

S4

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SUITE 400
SAN FRANCISCO, CA 94111
415.351.5151
ANCHORQEA.COM

eTrac
637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

PLOT DATE: JANUARY 12, 2018
DRAWN BY: NPJG | CHECKED BY: EM
CONTRACT #:
PERMIT #: EPISODE #:
PROJECT NAME:
ANCH_2017_Lake Temescal

Lake Temescal
Oakland, CA

DTM, CONTOURS, SOUNDINGS & TOPOGRAPHIC SHOTS

Reference Number:
S5

A

B

C

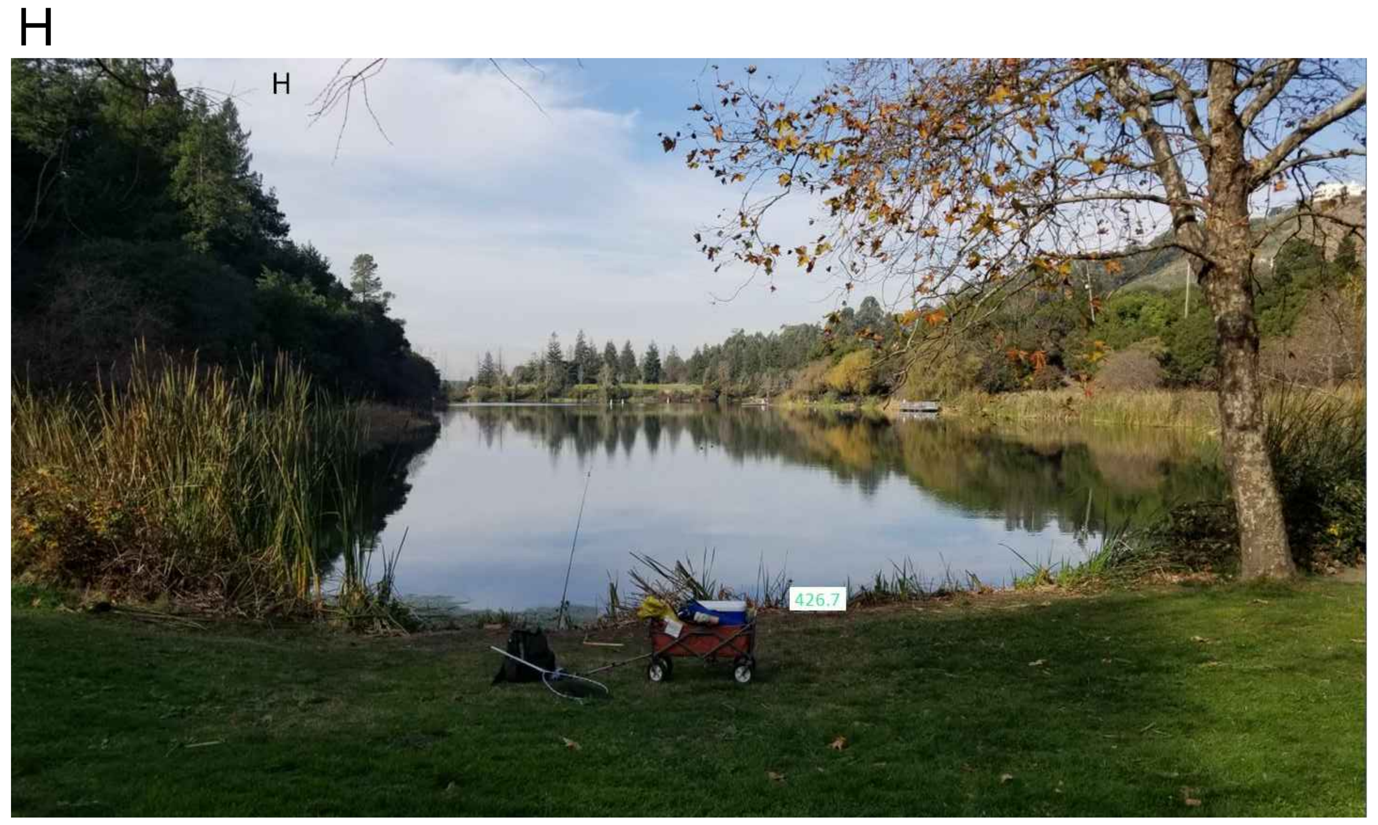
D

E

F

G

H



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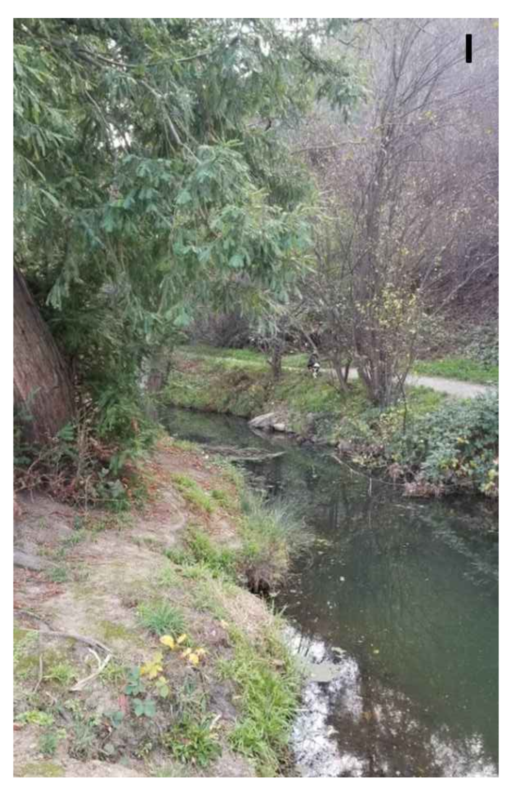

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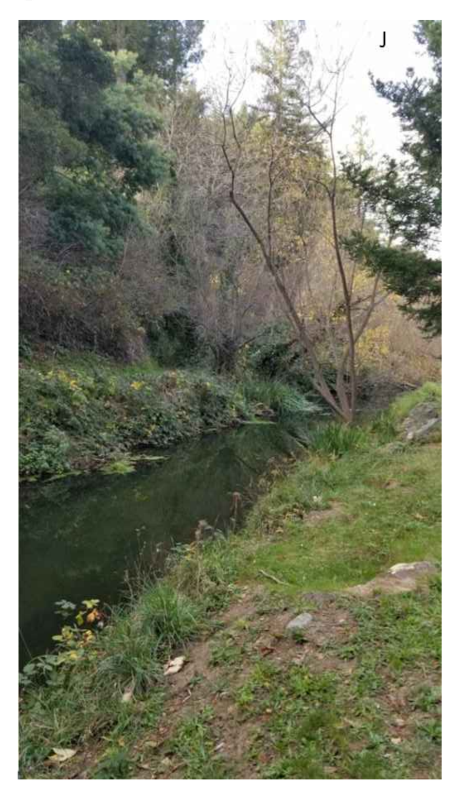

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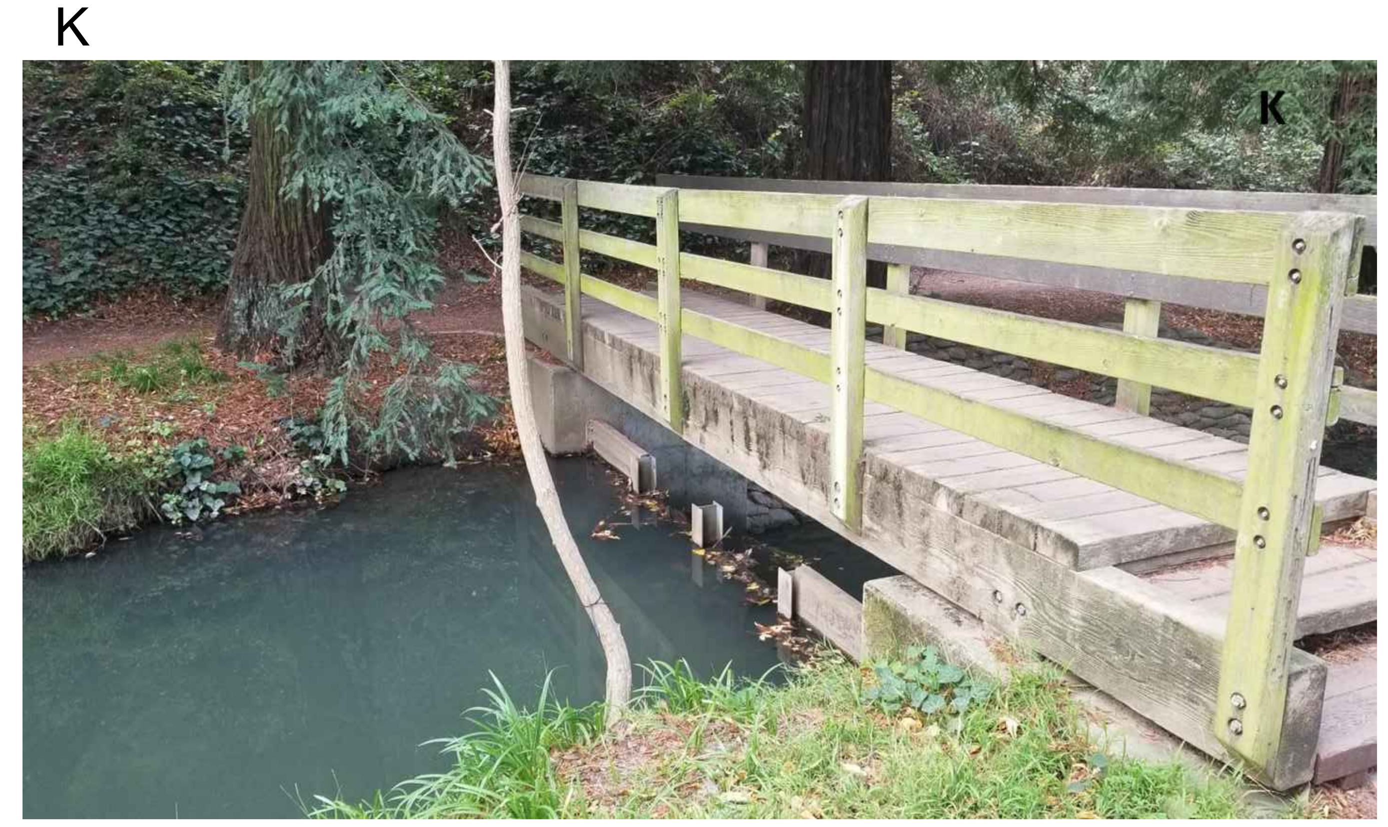

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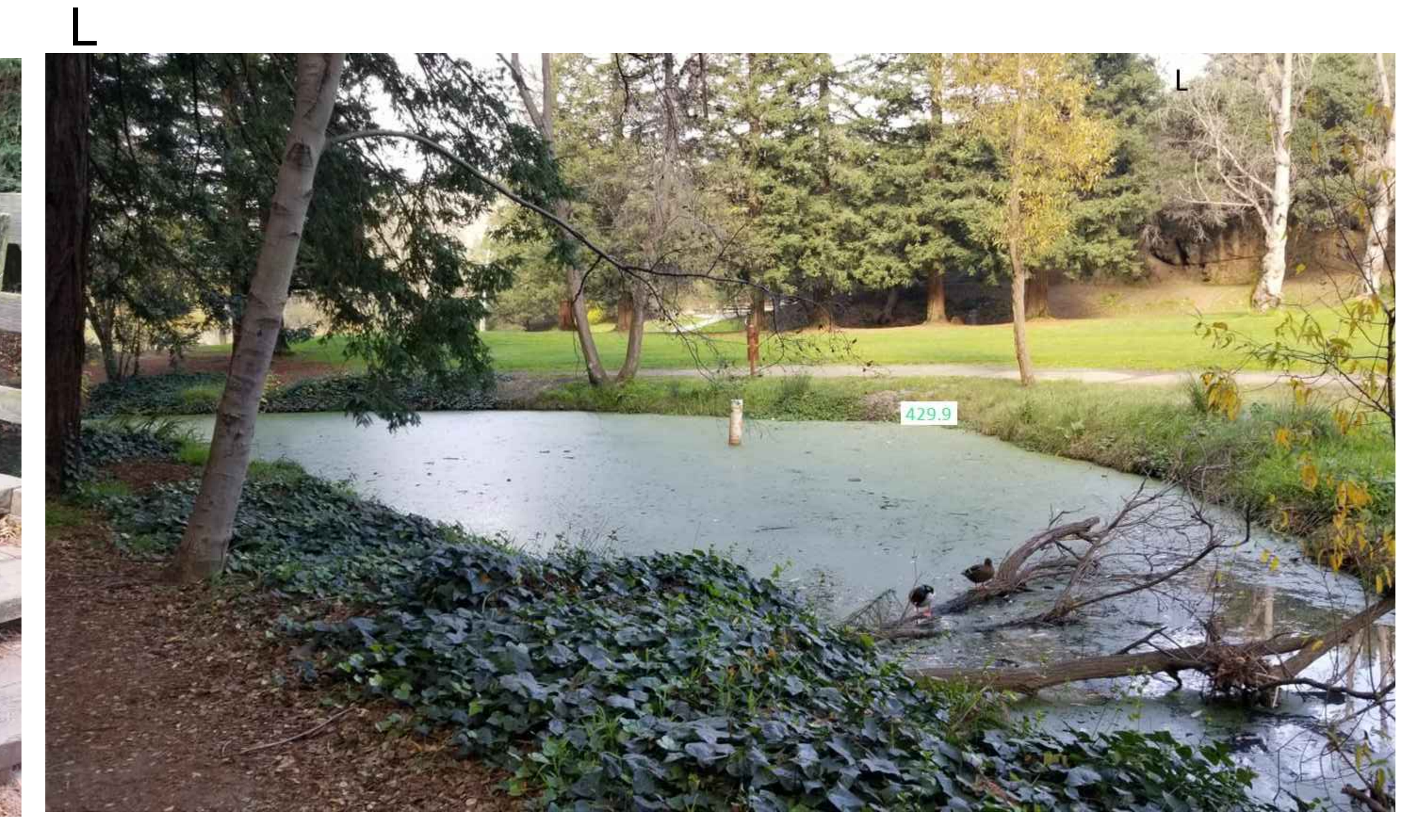

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eTrac
637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

PLOT DATE: JANUARY 12, 2018
DRAWN BY: NPJG | CHECKED BY: EM
CONTRACT #:
PERMIT #: EPISODE #:
PROJECT NAME:
ANCH_2017_Lake Temescal

Lake Temescal
Oakland, CA

PHOTOS

Reference Number:

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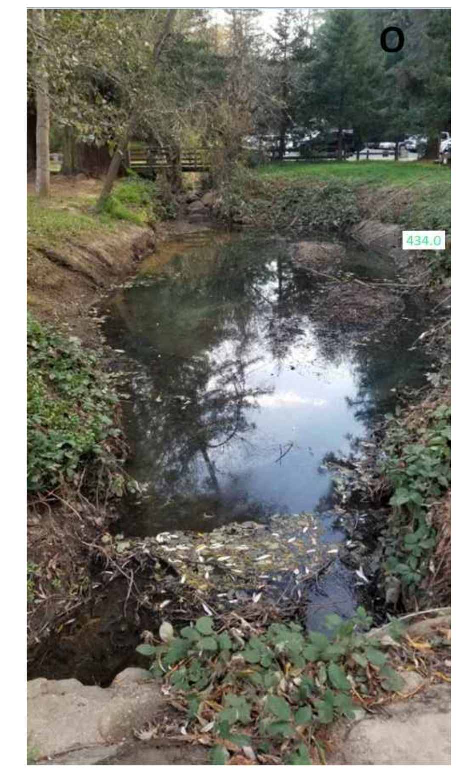

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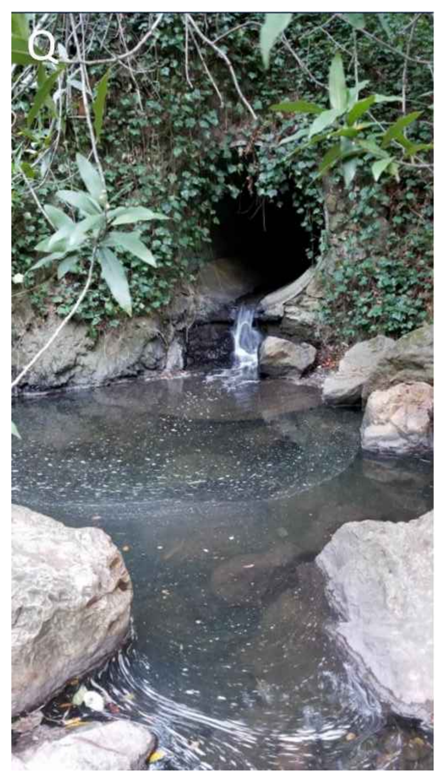

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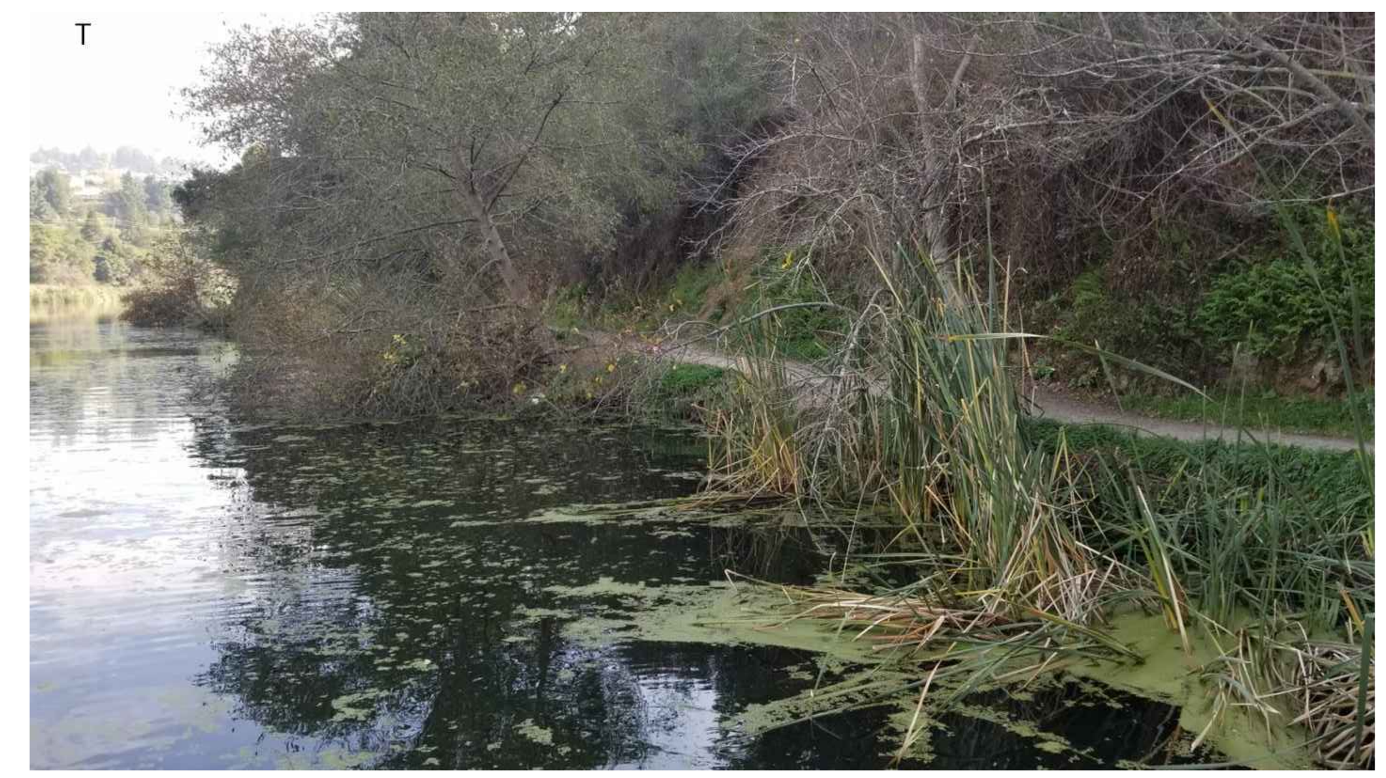

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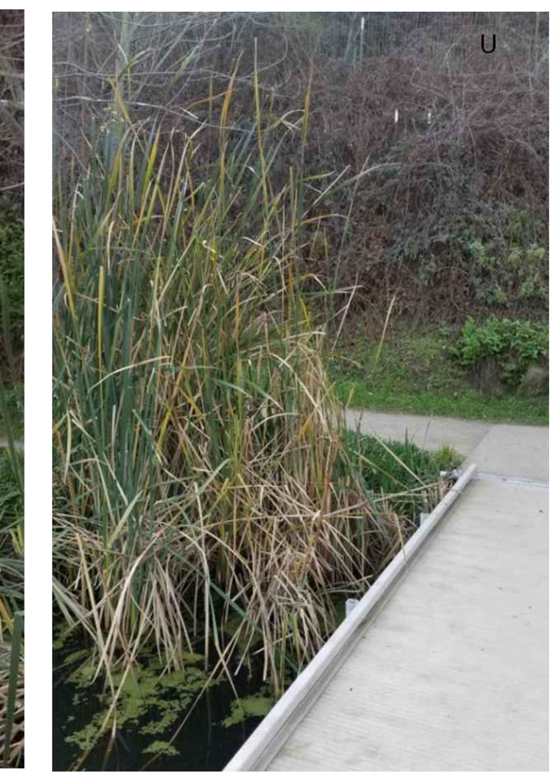

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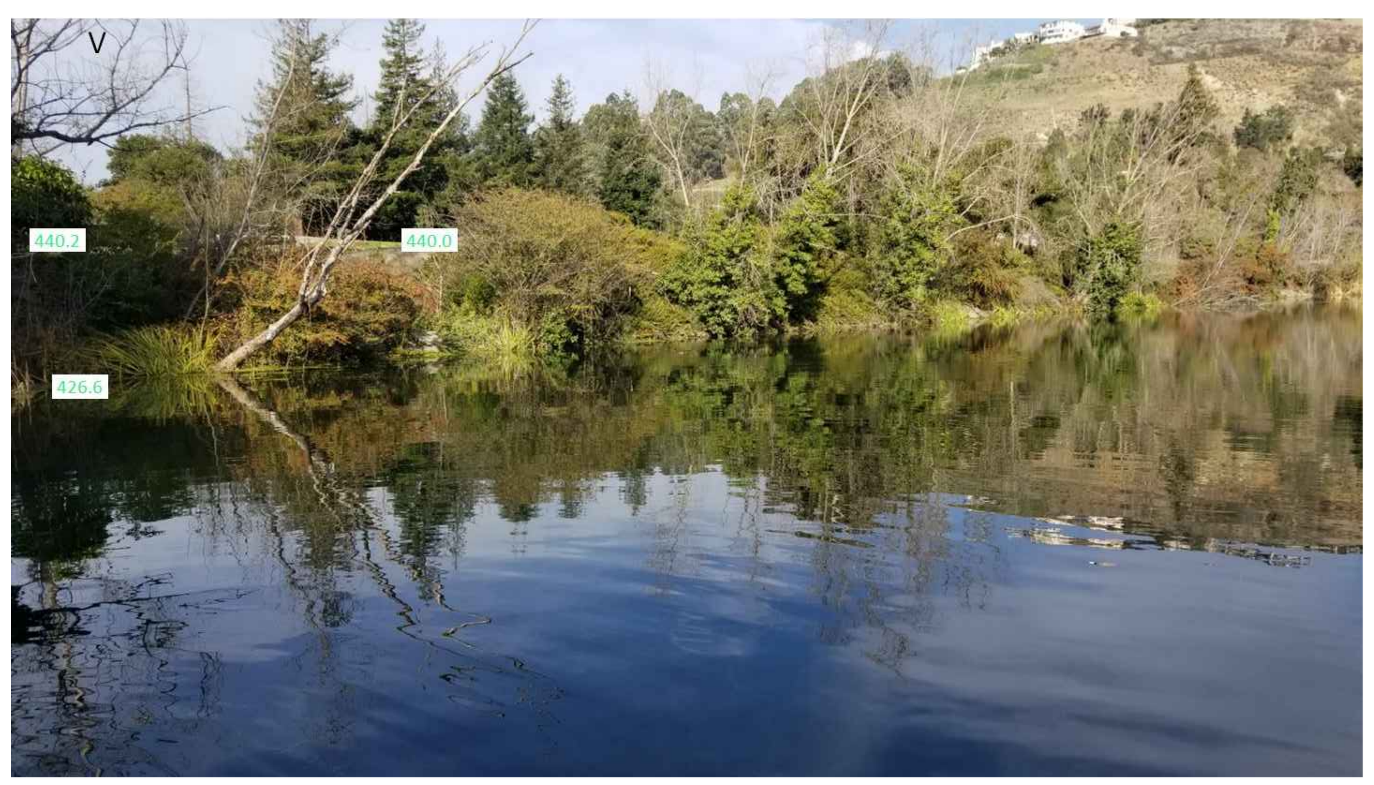

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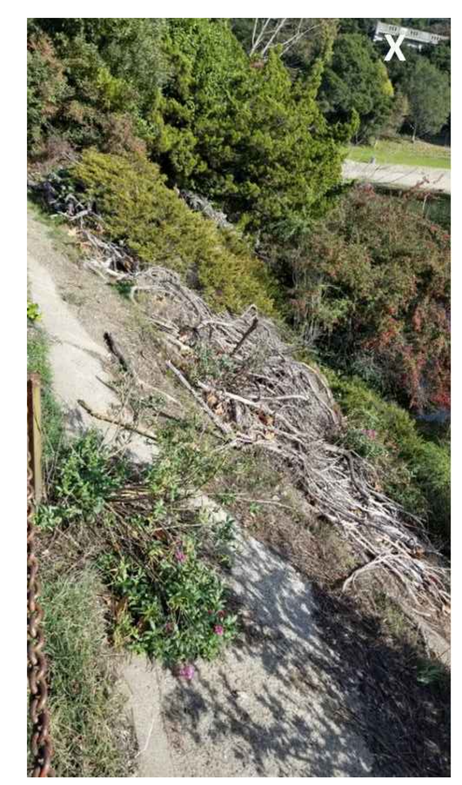

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CONTRACT #:
PERMIT #: EPISODE #:
PROJECT NAME:
ANCH_2017_Lake Temescal

Lake Temescal
Oakland, CA

PHOTOS

Reference Number:

S7

Appendix B
Lake Temescal Exploratory Sediment Sampling and Analysis Report

Attachment D: Laboratory Report is excluded due to length. The full version of Appendix B, including Attachment D, may be requested from EBRPD.

130 Battery Street, Suite 400
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Memorandum

June 21, 2018

To: Becky Tuden, East Bay Regional Park District

From: Jaclyn Gnusti, PE, and Chris Osuch, Anchor QEA, LLC

cc: Casey Brierley, East Bay Regional Park District

Re: Lake Temescal Exploratory Sediment Sampling and Analysis Report

Introduction

Lake Temescal is an artificial 10-acre lake located in Oakland, California (Figure 1). The lake was created in 1868 to provide drinking water for the East Bay. Today, the lake includes a public beach and is popular for swimming and fishing.

Lake Temescal is fed by Temescal and Caldecott Creeks, as well as stormwater from Highway 13. Three detention basins, including two at Temescal Creek and one at Caldecott Creek, are used to capture sediment. The capacity of Lake Temescal has been significantly reduced due to siltation. Poor circulation and nutrient-rich sediment has resulted in water quality impacts, including toxic algae blooms. The East Bay Regional Park District (EBRPD) is evaluating the feasibility of dredging Lake Temescal to improve water quality and circulation.

Exploratory sediment sampling and testing was performed at Lake Temescal to support the dredging feasibility study and evaluate potential placement and disposal options, including on-site upland or wetland cover material and local landfills. The sampling program was intended to be a preliminary investigation to determine general sediment quality at the site and was not designed to meet regulatory or landfill screening requirements. It is anticipated that additional sampling and testing would be required prior to dredging and disposal or reuse, which would extend to the maximum anticipated dredging depth. This memorandum summarizes the sediment sampling event and provides data results.

Field Collection Program

All sample collection, handling, and processing procedures were implemented in accordance with the *Lake Temescal Exploratory Sediment Sampling and Analysis Plan* (Anchor QEA 2018).

Sediment Collection

Sediment cores were collected on February 13 and 14, 2018. Sediment cores were collected from three stations using an electronic vibracore. Two stations were located near the Caldecott and

Temescal Creek inflows, and one station was located in the northern portion of the lake. Sampling locations are presented in Figure 2.

Sediment core sampling was performed from a platform deck with a tripod sitting atop two pontoons operated by Leviathan Environmental Services, Inc. The vibracore was deployed and recovered through a moonpool located in the middle of the platform. A differential GPS was used to guide the vessel to the pre-determined core sampling locations with an accuracy of plus or minus 10 feet. Sediment cores were collected at each sampling location to a target depth of 15 feet below the mudline or to refusal depth, whichever was encountered sooner. Station identification, coordinates, mudline elevation, and core lengths for each station are presented in Table 1.

Table 1
Station Identification, Coordinates, Mudline Elevation, Estimated Penetration, and Retrieved Core Length for Each Sampling Location

Station ID	Latitude (degrees, decimal minutes)[1]	Longitude (degrees, decimal minutes)[1]	Waterline Elevation (NAVD88)	Mudline Elevation (NAVD88)	Existing Water Depth (feet)	Estimated Penetration (feet)	Retrieved Core Length (feet)
LT-01	37° 50.823'	122° 13.894'	426.6	410.8	15.8	18.4[2]	14.0
LT-02	37° 50.769'	122° 13.779'	426.6	417.6	9.0	14.2[2]	9.9
LT-03	37° 50.714'	122° 13.737'	426.6	414.5	12.1	12.9[2]	10.3

Notes:
1. Based on North American Datum 1983 (NAD 83)
2. Refusal encountered

NAVD88: North American Vertical Datum of 1988

Sample Processing

Sediment core samples were processed landside. Physical characteristics of each core were noted on the individual sediment core collection form and each core was photographed. Core logs and photographs are provided in Attachments A and B, respectively.

Each core was vertically segmented, and samples were collected for sediment chemistry or archival. Volatile organic compounds (VOCs) were collected from one interval per location prior to homogenization to minimize loss of volatile constituents during handling. Samples for physical and chemical analysis were collected from the entire length of the core and individually homogenized to create a vertical composite. Subsamples were collected from each 5-foot interval and archived for potential chemical analysis to allow for better vertical resolution, if needed. Because of the potential need to dredge deeper than 15 feet below the mudline, the bottom 0.5 foot of each core was also archived. The bottom 0.5 foot could be used to infer the sediment quality of underlying material, if necessary. Sample intervals collected from each core are presented in Table 2.

All samples were temporarily stored in coolers with ice. Samples were picked up by courier and shipped overnight to Eurofins Calscience, Inc., located in Garden Grove, California, for analysis. Proper chain-of-custody procedures were followed.

Table 2
Sample Intervals Collected from Each Core

Station ID	Sample ID	Sample Interval (feet bgs)	Analysis
LT-01	LT-01-021318	0 to 14	Chemistry
	LT-01-1.0-1.5-021318	1 to 1.5	VOCs
	LT-01-0.0-5.0-021318	0 to 5	Archive
	LT-01-5.0-10.0-021318	5 to 10	Archive
	LT-01-10.0-14.0-021318	10 to 14	Archive
	LT-01-13.5-14.0-021318	13.5 to 14	Archive
LT-02	LT-02-021418	0 to 9.9	Chemistry
	LT-02-8.0-8.5-021418	8 to 8.5	VOCs
	LT-02-0.0-5.0-021418	0 to 5	Archive
	LT-02-5.0-9.9-021418	5 to 9.9	Archive
	LT-02-9.4-9.9-021418	9.4 to 9.9	Archive
LT-03	LT-03-021418	0 to 10.3	Chemistry
	LT-03-5.0-5.5-021418	5 to 5.5	VOCs
	LT-03-0.0-5.0-021418	0 to 5	Archive
	LT-03-5.0-10.0-021418	5 to 10	Archive
	LT-03-9.8-10.3-021418	9.8 to 10.3	Archive

Notes:
bgs: below ground surface

Physical and Chemical Analyses Results

Physical and chemical analyses of sediment in this testing program were selected to determine the general sediment quality at Lake Temescal and evaluate potential dredging placement and disposal options. Vertical composite samples from each station were submitted for analysis of total solids, grain size, total organic carbon (TOC), total petroleum hydrocarbons (TPH), metals, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, polychlorinated biphenyl (PCB) congeners, semivolatile organic compounds (SVOCs), and chlorinated herbicides. Metals included the California Title 22 Metals (CAM-17) to support the screening for landfill disposal. In addition, VOC samples were collected from one interval per location prior to homogenization to minimize loss of volatile constituents during handling. All analytical methods used followed U.S. Environmental Protection Agency (USEPA), Standard Method (SM), or ASTM protocols.

The grain size results are presented in Table C1 in Attachment C. Grain size of sediment from Station LT-01 consisted primarily of fines (95.7% silt and clay), while grain size of sediment from Stations LT-02 and LT-03 consisted primarily of sand (54.8 to 62.1%). TOC ranged from 1.4 to 2.5%. Metals, phthalates, PAHs, pesticides, PCB congeners, TPH, and VOCs were detected in sediment from Lake Temescal.

The vertical composite sediment chemistry results are also presented in Table C1 in Attachment C. All results were compared to standard screening levels for the three placement or disposal options: wetland cover, upland reuse, and landfill disposal. For the convenience of discussion, the screening level exceedances are summarized in the following sections. VOC results are presented in Table C2 in Attachment C. Method detection limits, reporting limits, and raw data for the analyses are presented in the laboratory report included as Attachment D.

Screening for Wetland Cover

Sediment chemistry results were compared to Threshold Effect Levels (TELs) and Probable Effect Levels (PELs) to screen for wetland cover material. TELs and PELs are sediment quality guidelines developed for freshwater ecosystems which indicate the potential for adverse effects (Buchman 2008).

A summary of contaminants that exceeded screening levels for wetland cover material (TEL and PEL values) is presented in Table 3. Several metals, PAHs, DDTs (4,4′-DDT and total DDTs), and total PCBs exceeded corresponding TEL values in at least one sample. TELs represent concentrations below which adverse effects are expected to occur (MacDonald et al. 2000). Exceedance of a TEL does not necessarily predict toxicity. PELs represent concentrations above which adverse effects are more likely to occur. Lead, mercury, nickel, DDTs (4,4′-DDD and 4,4′-DDE), and chlordane exceeded the corresponding PEL value in at least one sample. Nickel concentrations in sediment from Lake Temescal sediment are within the range of naturally occurring background concentrations in San Francisco Bay area soil (upper estimate of 272 milligrams per kilogram [mg/kg, based on the 99th percentile]; Lawrence Berkeley National Laboratory 2009), and therefore, not at a level of concern.

Table 3
Summary of Screening Level Exceedances for Wetland Cover Material

	TEL	PEL	LT-01	LT-02	LT-03
Metals (mg/kg)					
Arsenic	5.9	17.0	11.4	6.97	7.57
Cadmium	0.6	3.5	1.59	1.4	1.35
Chromium	37.3	90.0	59.9	36	38.3
Copper	35.7	197	72.1	42.1	51

	TEL	PEL	LT-01	LT-02	LT-03
Lead	35.0	91.3	91	114	88.4
Mercury	0.17	0.486	0.251	0.604	0.116
Nickel	18	36	73.8	51	52.6
Zinc	123	315	200	163	203
Organics (µg/kg)					
Benzo(a)anthracene	31.7	385	17 J	38	56
Benzo(a)pyrene	31.9	782	20	45	63
Chrysene	57.1	862	39	69	96
Dibenzo(a,h)anthracene	6.22	135	8.3 J	14 J	15 J
Fluoranthene	111	2,355	44	110	160
Phenanthrene	41.9	515	41	62	77
Pyrene	53.0	875	57	120	170
4,4'-DDD (p,p'-DDD)	3.54	8.51	92	40	82
4,4'-DDE (p,p'-DDE)	1.42	6.75	16	12	22
4,4'-DDT (p,p'-DDT)	1.19	4.77	1.1 J	3.8	7.5
Chlordane	4.50	8.87	29	32	280
Total DDx (U = 0)	7	4,450	127.1 J	69.5	175.5
Total PCB Congener (U = 0)	34.1	277	38.61	152.2	63.32

Notes:
Total DDx is the sum of 4,4'-DDD, 4,4'-DDE, 4,4'-DDT 2,4'-DDD, 2,4'-DDE, and 2,4'-DDT, if measured.
Total PCB congeners is the sum of all PCB congeners listed in this table.
(green) Detected concentration is greater than TEL screening level
(yellow) Detected concentration is greater than TEL and PEL screening levels
µg/kg: micrograms per kilogram
J: estimated value
mg/kg: milligrams per kilogram
PCB: polychlorinated biphenyls
U: compound analyzed, but not detected above detection limit

Screening for Upland Reuse

Sediment chemistry results were compared to Environmental Screening Levels (ESLs) to screen for on-site upland reuse. ESLs were developed by the San Francisco Bay Regional Water Quality Control Board to establish bay-wide environmental screening values for sites with contaminated soil and groundwater (SFRWQCB 2016). ESLs are intended to help expedite the identification of potential environmental concerns, including human health concerns.

A summary of contaminants that exceeded screening levels for upland reuse (ESLs) is presented in Table 4. Arsenic, lead, dimethyl phthalate, and benzo(a)pyrene exceeded the corresponding ESL in at least one sample. Arsenic concentrations in Lake Temescal sediment are consistent with naturally occurring background concentrations in soil for San Francisco Bay area (upper estimate of 11 mg/kg [based on the 99th percentile]; Duverge 2011), and therefore, not at a level of concern. The Tier I ESLs for lead and benzo(a)pyrene are based on human health risk levels for residential shallow soil exposure. Lead and benzo(a)pyrene concentrations are below the any land use/any depth construction worker ESLs (160 mg/kg and 1,600 micrograms per kilogram, respectively), and therefore, may be suitable for some reuse options (e.g., foundation material). The Tier I ESL for dimethyl phthalate is based on potential impacts to groundwater from leaching. Depending on the depth to groundwater at the reuse site, this screening level may be conservative.

Table 4
Summary of Screening Level Exceedances for Upland Reuse

	Tier I Soil ESL	LT-01	LT-02	LT-03
Metals (mg/kg)				
Arsenic	0.067	11.4	6.97	7.57
Lead	80	91	114	88.4
Organics (µg/kg)				
Dimethyl phthalate	35	240 J	210 J	*200 U*
Benzo(a)pyrene	16	20	45	63

Notes:
[yellow shading] Detected concentration is greater than Tier 1 ESL Soil screening level
Italicized: Non-detected concentration is above one or more identified screening levels
µg/kg: micrograms per kilogram
J: estimated value
mg/kg: milligrams per kilogram
U: compound analyzed, but not detected above detection limit

Screening for Landfill Disposal

Sediment chemistry results were compared to Total Threshold Limit Concentrations (TTLCs) and leachate trigger levels to screen for landfill disposal. TTLCs indicate the level above which material must be managed as hazardous waste upon removal, in accordance with Title 22 of the California Code of Regulations (CCR). As part of the screening for landfill disposal, sediment chemistry results were also compared to leachate trigger levels to determine whether leachate tests would be required. TTLCs and leachate tests (Waste Extraction Test [WET] or toxicity characteristic leaching procedure [TCLP]) are both used to determine whether a material is a hazardous waste. The TTLC analysis is typically performed first and determines the total concentration in a sample. If TTLCs are exceeded, the material is classified as a hazardous waste and no further testing is required. If TTLCs are not exceeded, total sediment concentrations are used to evaluate the maximum theoretical leachate concentration and determine whether actual leachate tests are required. To determine whether leachate tests would be required, sediment chemistry results were compared to 20 times the

TCLP regulatory values and 10 times the soluble threshold limit concentrations (STLCs). These factors are based on the liquid-to-solid ratios of 20:1 and 10:1 used in TCLP and WET, respectively (Cal/EPA DTSC 2018). If sediment chemistry indicates contaminants are not present or present at such low concentrations that TCLP regulatory levels or STLCs could not possibly be exceeded, leachate tests would not need to be run (USEPA 1994). It is only necessary to perform actual TCLP and/or WET for samples in which analytes exceed these criteria.

A summary of contaminants that exceeded screening levels for landfill disposal is presented in Table 5. All sediment concentrations were less than TTLCs; however, chromium and lead exceeded 10 times the STLC in at least one sample. Lead also exceeded 20 times the TCLP regulatory level in one sample. These results indicate that leachate testing would be required prior to landfill disposal. Herbicides were not detected in sediment from Lake Temescal.

Table 5
Summary of Screening Level Exceedances for Landfill Disposal

	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	LT-01	LT-02	LT-03
Metals (mg/kg)						
Chromium	2,500	50	100	59.9	36	38.3
Lead	1,000	50	100	91	114	88.4

Notes:
(green) Detected concentration is greater than 10 x STLC screening level
(yellow) Detected concentration is greater than 10 STLC and 20 x TCLP screening levels
mg/kg: milligrams per kilogram

Quality Assurance and Quality Control

A review of analytical results was conducted to evaluate the laboratories' performance in meeting data quality objectives (Attachment E). The QA/QC summary is as follows:

- Holding times were met (from sampling date to preparation and preparation to analysis).
- Method blanks were analyzed at the required frequencies, and all method blanks were free of target analytes.
- A trip blank was analyzed for VOCs and was free of target analytes.
- Surrogates were added to all field and QC samples as required, and recoveries were within laboratory control limits, with one exception.
  - The herbicide surrogate was above the control limit in the analyses of samples LT-01 and LT-03. Herbicides were not detected in the parent samples; therefore, data are not expected to be affected.

- Laboratory control samples were analyzed at the required frequency, and recoveries were within laboratory control limits.
- Matrix spike (MS) and matrix spike duplicate (MSD) samples were analyzed at the required frequencies, and recoveries and/or relative percent difference (RPD) values were within laboratory control limits, with the following exceptions.
  - The MS and MSD percent recoveries for zinc and barium could not be calculated in sample LT-01 because sample concentrations were greater than four times the spike concentration. Data are not expected to be affected.
  - The MS and MSD percent recoveries for antimony were below the control limit in sample LT-01. Associated sample results were non-detect; therefore, the reported limit may be estimated.
  - The MS and/or MSD percent recoveries and/or RPD values for six pesticides (beta-BHC, delta-BHC, 4,4′-DDD, heptachlor epoxide, methoxychlor, and alpha chlordane) were above the laboratory control limit in sample LT-02. Detected concentrations may have a potentially high bias.
  - The MSD percent recoveries for 4,4′-DDE and 4,4′-DDT were below the control limit and the RPD was above the control limit in sample LT-02. The MSD percent recovery for gamma chlordane was also below the control. Associated sample results may have a potentially low bias.
  - The MS and MSD percent recoveries for 4,4′-DDT and methoxychlor were below the control limit in sample LT-01. Associated sample results were non-detect; therefore, the reported limit may be estimated.
- A laboratory duplicate was analyzed for total solids, and the RPD value was within laboratory control limits.

QA/QC results indicate that the quality of the data is acceptable.

Summary

The following is a summary of anticipated testing results and application to various sediment placement options:

- Wetland Reuse
  - PEL exceedances indicate the potential for adverse effects and could be an issue for wetland cover, but agency coordination would be required to confirm acceptable levels.
- Upland Placement/Reuse
  - ESL exceedances could be an issue for upland placement; however, this depends on specific site conditions and land uses at the reuse site. Agency coordination would be required to confirm acceptable levels.

- Landfill Disposal
  - No TTLCs were exceeded; therefore, based on this initial screening, sediments are not classified as hazardous.
  - However, based on elevated lead and chromium concentrations over 10 times the STLC and/or 20 times the TCLP regulatory level, additional leachate testing would be required to confirm this designation. We recommend working with the Water Board, and other stakeholder regulatory agencies, to develop a leachate testing approach when the dredging plan is further developed.

The results of sediment testing for each composite core will be further discussed during development of the dredging plan to assess various dredging considerations, such as vertical and horizontal extents, as well as application to the disposal options.

References

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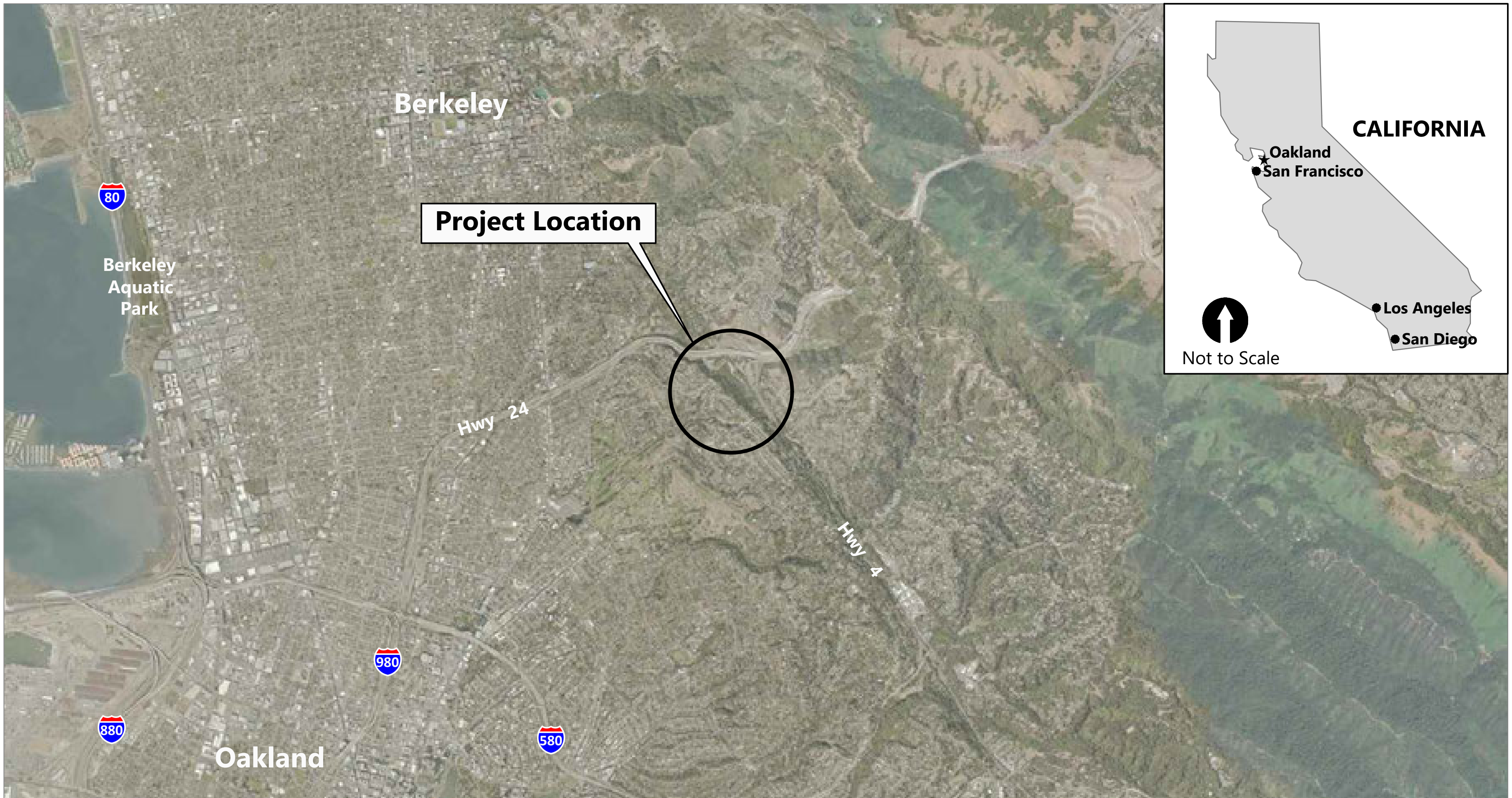
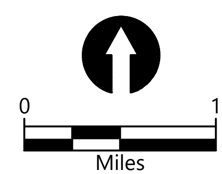
USEPA (U.S. Environmental Protection Agency), 1994. *Use of Total Waste Analysis in Toxicity Characteristic Determinations*. EPA: 540-R-94-005a.

Figures



SOURCE: Aerial from Bing maps 2018.
HORIZONTAL DATUM: California State Plane, Zone3, NAD83, U.S. Feet.

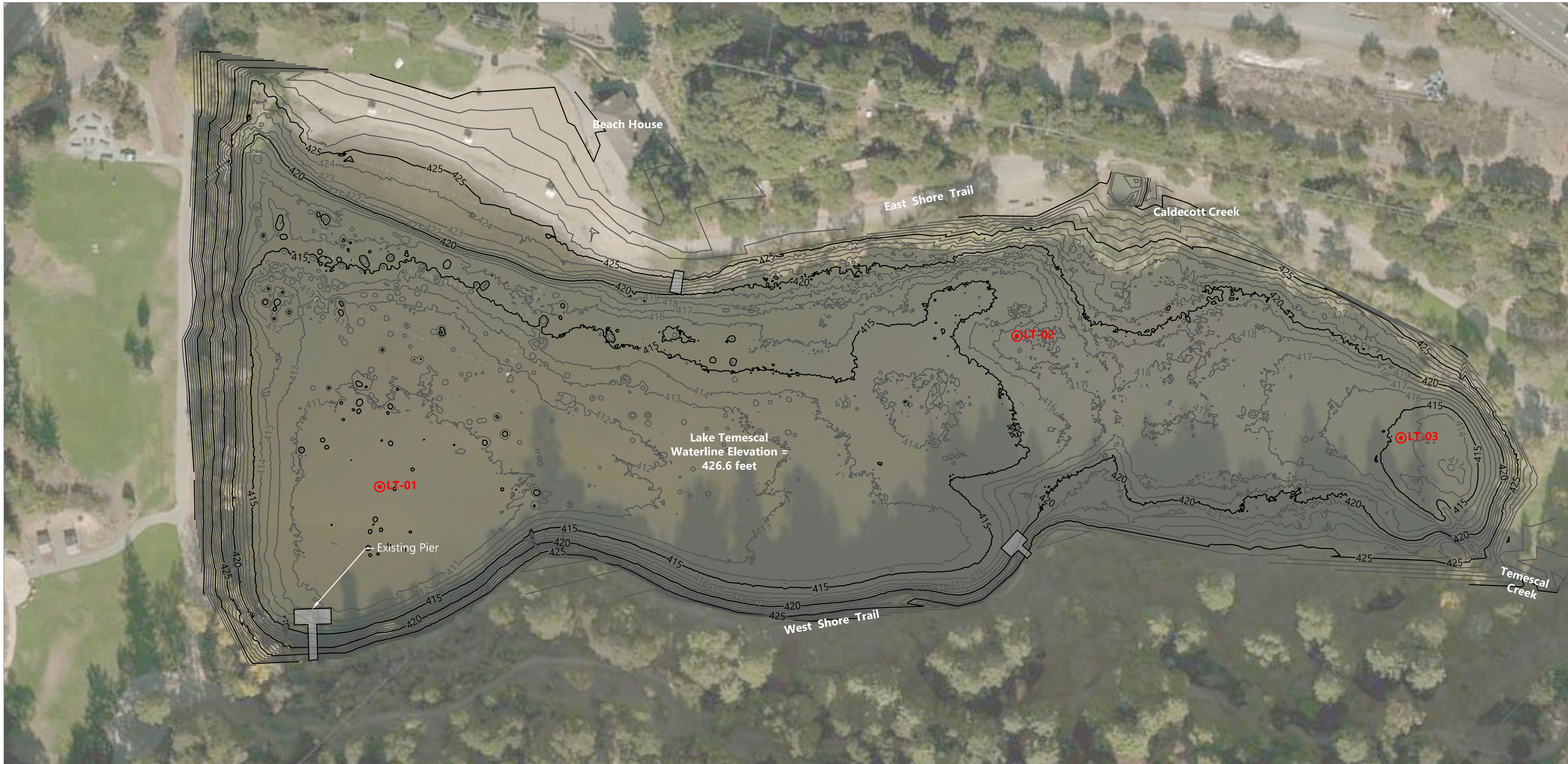


Publish Date: 2018/01/04 3:14 PM | User: mpratschner
Filepath: K:\Projects\1751-East Bay Regional Park District\Lake Temescal Dredging\1751 RP-001 VIC MAP.dwg FIG 1

ANCHOR QEA

Figure 1
Vicinity Map

Lake Temescal Dredging Feasibility Study



SOURCE: Aerial from Bing maps. Bathymetry from eTrac Inc., survey dated 2017.
HORIZONTAL DATUM: California State Plane, Zone 3, NAD83, U.S. Feet.
VERTICAL DATUM: NAVD88

LEGEND:

—420—	Existing Contour (5 ft)
LT-#	Actual Sampling Location

0 100
Feet

Publish Date: 2018/03/21 2:30 PM | User: mpratschner
Filepath: K:\Projects\1751-East Bay Regional Park District\Lake Temescal Dredging\1751 RP-003 ACTUAL SAMPLING.dwg FIG 2

ANCHOR QEA

Figure 2
Existing Bathymetry and Actual Sampling Locations
Lake Temescal Dredging Feasibility Study

Attachment A

Core Logs

Sediment Core Collection Form

ANCHOR QEA

Project	Lake Temescal	Date 2/13/18	Time 1023
Station ID	LT-01	Latitude 37°50.823	Longitude 122°13.894
Type of Core	Vibracore	Water Depth (ft) 15.8	Tide (ft) N/A
Mudline Elevation (~~ft MLLW~~ NAVD88)	410.8	Target Core Length (ft) 15	
Project Depth+Overdepth (ft ~~MLLW~~)	N/A	Penetration Length (ft) 18.4	Core Recovery (ft) 14.0

Depth In (ft.) Core Sections / Actual	Sample Interval	Classification and Remarks (Color, Consistency, Moisture, Grain Size, Sheen, Odor)
0–2	LT-01 (chem); LT-01-0.0-5.0 (archive); LT-01-1.0-1.5 (VOC)	Black, very soft, wet, SILT; w/ gray streak @ 0.7
2–4.9		Gray w/ black streaks throughout, soft, moist
4.9–7.5	LT-01-5.0-10.0 (archive)	gray, medium stiff
7.3		w/ organic (plant fibers) lense @ 7.3'
7.5–10		stiff
9.0, 9.7		w/ black streaks @ 9.0 and 9.7

14 No. Photos Taken　　Recorded By: C. Osuch　　Attempt No. 1 of 1

Sediment Core Collection Form

ANCHOR QEA

Project	Lake Temescal	Date	2/13/18 Time 1023
Station ID	LT-01	Latitude	37°50.823 Longitude 122°13.894
Type of Core	Vibracore	Water Depth (ft)	15.8 Tide (ft) N/A
Mudline Elevation (~~ft MLLW~~) (NAVD88)	410.8	Target Core Length (ft)	15.0
Project Depth+Overdepth (~~ft MLLW~~)	N/A	Penetration Length (ft)	18.4 Core Recovery (ft) 14.0

Depth In (ft.) Core Sections / Actual	Sample Interval	Classification and Remarks (Color, Consistency, Moisture, Grain Size, Sheen, Odor)
	LT-01 (cont.) ↓; LT-01-10.0-14.0 (archive) ↓	Gray stiff moist SILT ↓ w/ black streak ~~from~~ 10.6 to 10.8
11		
12		
13	LT-01-13.5-14.0 (archive)	
14		
15		
16		
17		
18		
		Refusal @ 18.4
19		

14 No. Photos Taken Recorded By: C. Osuch Attempt No. ~~1~~ 4 of 1

Sediment Core Collection Form

ANCHOR QEA

Project	Lake Temescal	Date 2/14/18	Time 0949
Station ID	LT-02	Latitude 37°50.769'	Longitude 122°13.779'
Type of Core	vibracore	Water Depth (ft) 9.0	Tide (ft) N/A
Mudline Elevation (~~ft MLLW~~ NAVD88)	417.6	Target Core Length (ft) 15	
Project Depth+Overdepth (~~ft MLLW~~)	N/A	Penetration Length (ft) 14.2	Core Recovery (ft) 9.9

Depth In (ft.) Core Sections / Actual	Sample Interval	Classification and Remarks (Color, Consistency, Moisture, Grain Size, Sheen, Odor)
0–1	LT-02 (chem); LT-02-0.0-5.0 (archive)	Black, very soft ~~soft~~, wet, SILT w/ occasional organics (plant material) to 0.8
1–2.4		Black w/ gray streaks, medium stiff, moist
2.4		Gray, 2.4–2.6 medium dense, 2.4–2.6 f-SAND w/ organic (plant fibers) lense @ 2.4
2.6–3.5		medium stiff, slightly sandy SILT
3.5–5.0		SILT w/ sand lense @ 4.5
5.0–6.7	LT-02-5.0-9.9 (archive)	Greenish gray, dense, slightly gravely m-c SAND
6.7–7.1		light gray, stiff, CLAY
7.1–8.7	LT-02-8.0-8.5 (VOC) 8.0–8.5	gray, stiff, slightly sandy SILT w/ trace organics, w/ trace metallic sheen 7-7.8'
8.7–9.1		dense, f-SAND w/ trace gravel
9.1–9.9	9.4 LT-02-9.4-9.9 (archive)	gray w/ black, stiff, CLAY
9.9		

10 No. Photos Taken   Recorded By: C. Osuch   Attempt No. 1 of 1

Refusal @ 14.2

page 1 of 1

Sediment Core Collection Form

ANCHOR QEA

Project	Lake Temescal	Date	2/14/18
Station ID	LT-03	Time	0802
Type of Core	Vibracore	Latitude	37°50.714'
Mudline Elevation (ft MLLW) ~~(ft NAVD88)~~	444.5	Longitude	122°13.737
Project Depth+Overdepth (ft MLLW)	N/A	Water Depth (ft)	12.1
		Tide (ft)	N/A
		Target Core Length (ft)	15
		Penetration Length (ft)	12.9
		Core Recovery (ft)	10.3

Depth In (ft.) Actual / Core Sections	Sample Interval	Classification and Remarks (Color, Consistency, Moisture, Grain Size, Sheen, Odor)
0–1	LT-03 (chem) 0.0–10.3; LT-03-0.0-5.0 (archive)	Black very soft wet SILT w/ substantial organics (plant material) to 0.5
1–2.7		Black w/ gray streaks throughout, soft
2.7–5.7		gray w/ black streaks, ~~soft~~ medium stiff, moist; w/ organic lense @ 4.0 (plant fiber); w/ organic lense @ 5.0 (plant fiber)
5.0–5.5	LT-03-5.0-5.5 (VOCs)	
5.7–8	LT-03-5.0-10.0 (archive)	gray stiff; w/ black @ 7.1; w/ organic lense @ 7.1 (plant fiber, wood chips)
8–9.5		dense; silty vf-f SAND
9.5–10.3	LT-03-9.8-10.3 (archive)	very dense; vf-f SAND w/ ~~little~~ trace silt w/ trace organics (plant material) and trace gravel

15 No. Photos Taken

Recorded By: C. Osuch

Attempt No. 1 of 1

Refusal @ 12.9'

page 1 of 1

Attachment B

Core Photographs

Attachment B: Core Photographs

LT-01 (0 to 2 feet)

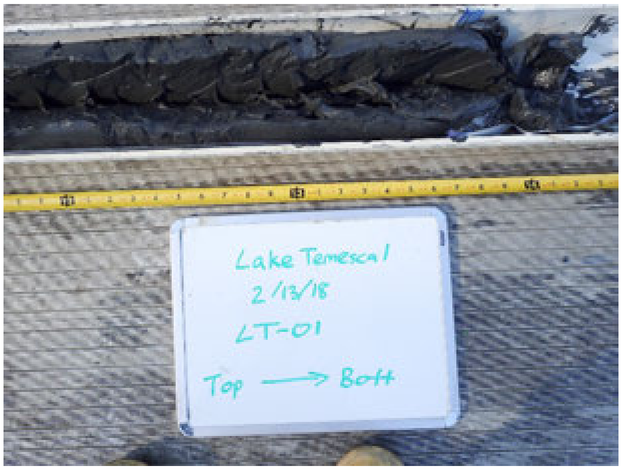
LT-01 (2 to 4 feet)

LT-01 (4 to 6 feet)

LT-01 (6 to 8 feet)

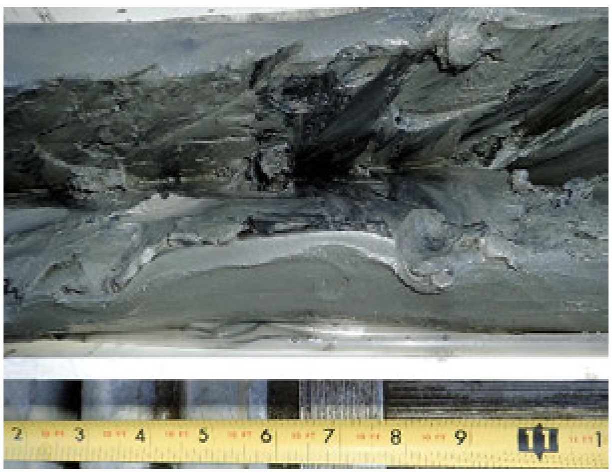
LT-01 (8 to 10 feet)

LT-01 (10 to 12 feet)



LT-01 (12 to 14 feet)

LT-01
subsample of gray with black streaks from 2 to 4.9 feet

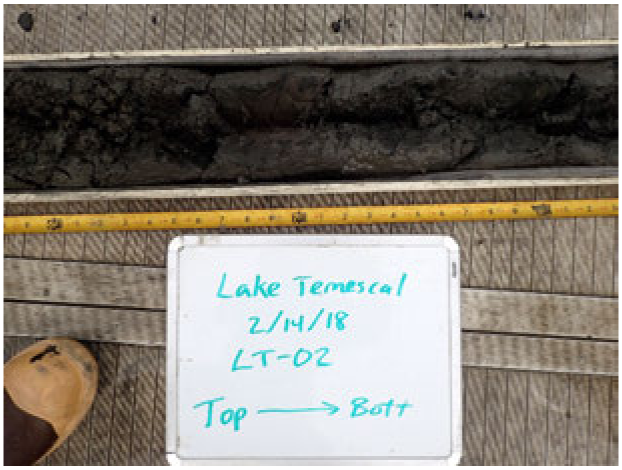


LT-01
black streak at 10.7 feet

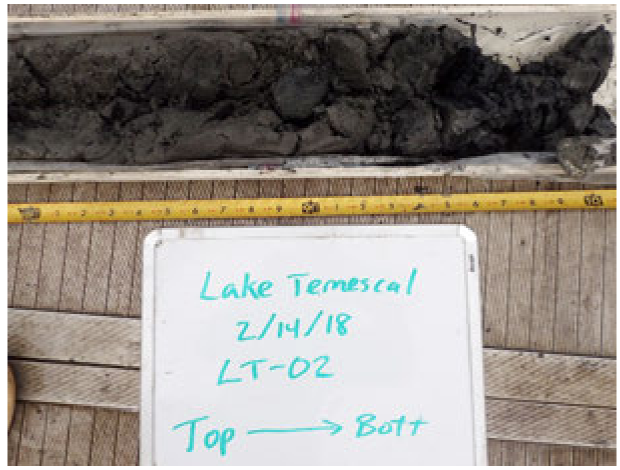
LT-02 (0 to 2 feet)

LT-02 (2 to 4 feet)

LT-02 (4 to 6 feet)



LT-02 (6 to 8 feet)

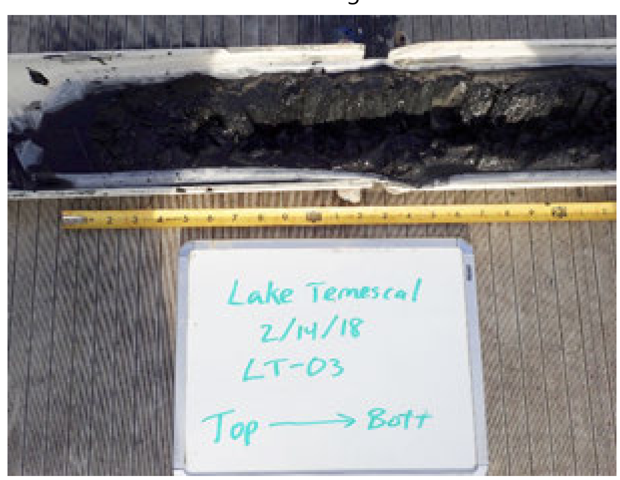


LT-02 (8 to 10 feet)


LT-02
gray silt from 3.5 to 4.5 feet


LT-02
medium to coarse sand with gravel from 5 to 6 feet


LT-02
metallic sheen from 7 to 7.8 feet



LT-03 (0 to 2 feet)

LT-03 (2 to 4 feet)

LT-03 (4 to 6 feet)

LT-03 (6 to 8 feet)

LT-03 (8 to 10 feet)

LT-03
gray with black streaks from 5 to 6 feet

LT-03
very fine to fine sand with silt from 9.3 to 10.3 feet

Attachment C

Sediment Chemistry Tables

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft
Conventional Parameters (pct)									
Total organic carbon	--	--	--	--	--	--	**1.8**	**1.4**	**2.5**
Total solids	--	--	--	--	--	--	**51.1**	**65**	**55.2**
Grain Size (pct)									
Gravel (>2mm)	--	--	--	--	--	--	0.01 U	0.01 U	0.01 U
Sand (2.00mm - 1.00mm)	--	--	--	--	--	--	0.01 U	**1.52**	0.01 U
Sand, coarse	--	--	--	--	--	--	0.01 U	**6.93**	**2.46**
Sand, medium	--	--	--	--	--	--	0.01 U	**8.53**	**4.93**
Sand, fine	--	--	--	--	--	--	**0.72**	**20.64**	**17.05**
Sand, very fine	--	--	--	--	--	--	**3.56**	**24.5**	**30.33**
Silt	--	--	--	--	--	--	**63.06**	**30.61**	**38.22**
Clay, <5 micron	--	--	--	--	--	--	**32.65**	**7.27**	**7.01**
Metals (mg/kg)									
Antimony	--	--	500	150	--	31	**0.414J**	**0.277J**	**0.414J**
Arsenic	5.9	17.0	500	50	100	0.067	**11.4**	**6.97**	**7.57**
Barium	--	--	10,000	1,000	2,000	3,019	**303**	**175**	**191**
Beryllium	--	--	75	7.5	--	41.5	**0.957J**	**0.546**	**0.714J**
Cadmium	0.6	3.5	100	10	20	39	**1.59**	**1.4**	**1.35**
Chromium	37.3	90.0	2,500	50	100	--	**59.9**	**36**	**38.3**
Chromium VI	--	--	500	50	--	0.30	*0.39 U*	*0.31 U*	*0.36 U*
Cobalt	--	--	8,000	800	--	23	**15.1**	**12.1**	**11.6**
Copper	35.7	197	2,500	250	--	3,100	**72.1**	**42.1**	**51**
Lead	35.0	91.3	1,000	50	100	80	**91**	**114**	**88.4**
Molybdenum	--	--	3,500	3,500	--	391	**2.76**	**2.43**	**2.22**
Mercury	0.17	0.486	20	2	4	13	**0.251**	**0.604**	**0.116**

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft
Nickel	18	36	2000	200	--	86	**73.8**	**51**	**52.6**
Selenium	--	--	100	10	20	390	**1.29**	**0.839**	**0.881**
Silver	--	--	500	50	100	391	**0.316**	**0.205**	**0.223**
Thallium	--	--	700	70	--	0.78	**0.333**	**0.215**	**0.239**
Vanadium	--	--	2,400	240	--	393	**66.9**	**41.8**	**44.4**
Zinc	123	315	5,000	2,500	--	23,000	**200**	**163**	**203**
Semivolatile Organics (µg/kg)									
1,2,4-Trichlorobenzene	--	--	--	--	--	1,500	120 U	90 U	110 U
1,2-Dichlorobenzene	--	--	--	--	--	1,600	120 U	97 U	110 U
1,3-Dichlorobenzene	--	--	--	--	--	7,400	140 U	110 U	130 U
1,4-Dichlorobenzene	--	--	--	--	150,000	590	150 U	110 U	130 U
2,2'-Oxybis (2-chloropropane)	--	--	--	--	--	--	110 U	87 U	100 U
2,4,5-Trichlorophenol	--	--	--	--	8,000,000	180	120 U	96 U	110 U
2,4,6-Trichlorophenol	--	--	--	--	40,000	210	150 U	120 U	140 U
2,4-Dichlorophenol	--	--	--	--	--	300	110 U	88 U	100 U
2,4-Dimethylphenol	--	--	--	--	--	670	520 U	400 U	480 U
2,4-Dinitrophenol	--	--	--	--	--	110	*660 U*	*510 U*	*610 U*
2,4-Dinitrotoluene	--	--	--	--	2,600	1.8	*130 U*	*100 U*	*120 U*
2,6-Dichlorophenol	--	--	--	--	--	--	120 U	90 U	110 U
2,6-Dinitrotoluene	--	--	--	--	--	--	140 U	110 U	130 U
2-Chloronaphthalene	--	--	--	--	--	--	120 U	90 U	110 U
2-Chlorophenol	--	--	--	--	--	12	*130 U*	*100 U*	*120 U*
2-Methylphenol (o-Cresol)	--	--	--	--	4,000,000	--	170 U	130 U	160 U
2-Nitroaniline	--	--	--	--	--	--	100 U	79 U	93 U
2-Nitrophenol	--	--	--	--	--	--	130 U	100 U	120 U

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft
3,3'-Dichlorobenzidine	--	--	--	--	--	12	*710 U*	*550 U*	*650 U*
3-Methylphenol & 4-Methylphenol (m&p-Cresol)	--	--	--	--	4,000,000	--	320 U	250 U	290 U
3-Nitroaniline	--	--	--	--	--	--	140 U	110 U	130 U
4-Bromophenyl-phenyl ether	--	--	--	--	--	--	120 U	93 U	110 U
4-Chloro-3-methylphenol	--	--	--	--	--	--	130 U	100 U	120 U
4-Chloroaniline	--	--	--	--	--	3.9	*130 U*	*99 U*	*120 U*
4-Chlorophenyl phenyl ether	--	--	--	--	--	--	130 U	97 U	120 U
4-Nitroaniline	--	--	--	--	--	--	130 U	99 U	120 U
4-Nitrophenol	--	--	--	--	--	--	110 U	82 U	97 U
Aniline	--	--	--	--	--	--	120 U	90 U	110 U
Azobenzene	--	--	--	--	--	--	110 U	82 U	97 U
Benzidine	--	--	--	--	--	--	1600 U	1300 U	1500 U
Benzoic acid	--	--	--	--	--	--	970 U	750 U	890 U
Benzyl alcohol	--	--	--	--	--	--	130 U	100 U	120 U
bis(2-Chloroethoxy)methane	--	--	--	--	--	--	110 U	85 U	100 U
bis(2-Chloroethyl)ether	--	--	--	--	--	0.080	*790 U*	*620 U*	*730 U*
bis(2-Ethylhexyl)phthalate	--	--	--	--	--	39,000	100 U	**280 J**	**290 J**
Butylbenzyl phthalate	--	--	--	--	--	--	110 U	82 U	97 U
Dibenzofuran	--	--	--	--	--	--	120 U	91 U	110 U
Diethyl phthalate	--	--	--	--	--	35	*110 U*	*88 U*	*100 U*
Dimethyl phthalate	--	--	--	--	--	35	**240 J**	**210 J**	*200 U*
Di-n-butyl phthalate	--	--	--	--	--	--	120 U	91 U	110 U
Dinitro-o-cresol (4,6-Dinitro-2-methylphenol)	--	--	--	--	--	--	1200 U	960 U	1100 U
Di-n-octyl phthalate	--	--	--	--	--	--	200 U	150 U	180 U
Hexachlorobenzene	--	--	--	--	2,600	340	130 U	100 U	120 U

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	--	--	--	--	10,000	680	120 U	96 U	110 U
Hexachlorocyclopentadiene	--	--	--	--	--	--	980 U	760 U	900 U
Hexachloroethane	--	--	--	--	60,000	1,100	150 U	120 U	140 U
Isophorone	--	--	--	--	--	--	110 U	86 U	100 U
Nitrobenzene	--	--	--	--	40,000	--	630 U	490 U	580 U
n-Nitrosodimethylamine	--	--	--	--	--	--	92 U	71 U	85 U
n-Nitrosodi-n-propylamine	--	--	--	--	--	--	160 U	130 U	150 U
n-Nitrosodiphenylamine	--	--	--	--	--	--	270 U	210 U	250 U
Pentachlorophenol	--	--	17,000	17,000	2,000,000	1,000	750 U	590 U	690 U
Phenol	--	--	--	--	--	76	*93 U*	73 U	*86 U*
Pyridine	--	--	--	--	100,000	--	110 U	83 U	98 U
Polycyclic Aromatic Hydrocarbons (µg/kg)									
1-Methylnaphthalene	--	--	--	--	--	--	**8.3 J**	**5.7 J**	4.1 U
1-Methylphenanthrene	--	--	--	--	--	--	4.8 U	**18**	4.4 U
2,3,5-Trimethylnaphthalene (1,6,7-Trimethylnaphthalene)	--	--	--	--	--	--	**14 J**	**17**	**8.4 J**
2,6-Dimethylnaphthalene	--	--	--	--	--	--	**64**	**30**	**42**
2-Methylnaphthalene	--	--	--	--	--	250	**16 J**	**10 J**	**5.5 J**
Acenaphthene	6.71	88.9	--	--	--	16,000	4.6 U	3.5 U	**4.4 J**
Acenaphthylene	5.87	128	--	--	--	13,000	3.5 U	2.7 U	3.2 U
Anthracene	46.9	245	--	--	--	2,800	**7.1 J**	**10 J**	**15 J**
Benzo(a)anthracene	31.7	385	--	--	--	160	**17 J**	**38**	**56**
Benzo(a)pyrene	31.9	782	--	--	--	16	**20**	**45**	**63**
Benzo(b)fluoranthene	--	--	--	--	--	160	**31**	**60**	**86**
Benzo(g,h,i)perylene	--	--	--	--	--	2,500	**18 J**	**34**	**45**

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft
Benzo(k)fluoranthene	--	--	--	--	--	1,600	**17 J**	**37**	**66**
Biphenyl (1,1'-Biphenyl)	--	--	--	--	--	650	**6.2 J**	**5.2 J**	**4.7 J**
Chrysene	57.1	862	--	--	--	3,800	**39**	**69**	**96**
Dibenzo(a,h)anthracene	6.22	135	--	--	--	16	**8.3 J**	**14 J**	**15 J**
Dibenzothiophene	--	--	--	--	--	--	2.6 U	**7.5 J**	**7.8 J**
Fluoranthene	111	2,355	--	--	--	60,000	**44**	**110**	**160**
Fluorene	21.2	144	--	--	--	8,900	**16 J**	**9.8 J**	**14 J**
Indeno(1,2,3-c,d)pyrene	--	--	--	--	--	160	**13 J**	**25**	**34**
Naphthalene	34.6	391	--	--	--	33	**8.1 J**	**7.1 J**	6.2 U
Perylene	--	--	--	--	--	--	**49**	**52**	**60**
Phenanthrene	41.9	515	--	--	--	11,000	**41**	**62**	**77**
Pyrene	53.0	875	--	--	--	85,000	**57**	**120**	**170**
Total HPAH (12 of 25) (U = 0)	--	--	--	--	--	--	**313.3 J**	**604 J**	**851 J**
Total LPAH (13 of 25) (U = 0)	--	--	--	--	--	--	**180.7 J**	**182.3 J**	**178.8 J**
Total PAH (25) (U = 0)	--	--	--	--	--	--	**494 J**	**786.3 J**	**1029.8 J**
Pesticides (µg/kg)									
2,4'-DDD (o,p'-DDD)	--	--	--	--	--	--	**11**	**6.2**	**35**
2,4'-DDE (o,p'-DDE)	--	--	--	--	--	--	**7**	**7.5**	**29**
2,4'-DDT (o,p'-DDT)	--	--	--	--	--	--	0.6 U	0.48 U	1.4 U
4,4'-DDD (p,p'-DDD)	3.54	8.51	--	--	--	2,700	**92**	**40**	**82**
4,4'-DDE (p,p'-DDE)	1.42	6.75	--	--	--	1,900	**16**	**12**	**22**
4,4'-DDT (p,p'-DDT)	1.19	4.77	--	--	--	1,900	**1.1 J**	**3.8**	**7.5**
Aldrin	--	--	1,400	1,400	--	36	0.84 U	0.66 U	2 U
Chlordane	4.50	8.87	2,500	2,500	600	480	**29**	**32**	**280**
Chlordane, alpha- (Chlordane, cis-)	--	--	--	--	--	--	**2.3**	**2.6**	**27**

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft
Chlordane, beta- (Chlordane, trans-)	--	--	--	--	--	--	**5**	**5.3**	**28**
Dieldrin	2.85	6.67	8,000	8,000	--	0.17	*0.84 U*	*0.66 U*	*2 U*
Endosulfan sulfate	--	--	--	--	--	--	1 U	0.79 U	2.3 U
Endosulfan, alpha- (I)	--	--	--	--	--	--	0.76 U	0.6 U	1.8 U
Endosulfan, beta (II)	--	--	--	--	--	--	0.9 U	0.71 U	2.1 U
Endrin	2.67	62.4	200	200	400	0.65	*0.92 U*	*0.73 U*	*2.1 U*
Endrin aldehyde	--	--	--	--	--	--	1.2 U	0.92 U	2.7 U
Endrin ketone	--	--	--	--	--	--	0.96 U	0.76 U	2.2 U
Heptachlor	--	--	4,700	4,700	160	0.77	*0.83 U*	0.66 U	*1.9 U*
Heptachlor epoxide	0.60	2.74	4,700	4,700	--	0.42	*1.4 U*	*1.1 U*	*3.3 U*
Hexachlorocyclohexane (BHC), alpha-	--	--	--	--	--	--	1.4 U	1.1 U	3.3 U
Hexachlorocyclohexane (BHC), beta-	--	--	--	--	--	--	0.95 U	0.75 U	2.2 U
Hexachlorocyclohexane (BHC), delta-	--	--	--	--	--	--	1.7 U	1.3 U	3.9 U
Hexachlorocyclohexane (BHC), gamma- (Lindane)	0.94	1.38	4,000	4,000	8,000	9.8	0.85 U	0.68 U	*2 U*
Kepone	--	--	21,000	21,000	--	--	1.5 U	1.1 U	1.4 U
Methoxychlor	--	--	100,000	100,000	200,000	19,000	1.1 U	0.84 U	2.5 U
Mirex	--	--	21,000	21,000	--	--	0.63 U	0.5 U	1.5 U
Nonachlor, cis-	--	--	--	--	--	--	0.49 U	0.39 U	1.2 U
Nonachlor, trans-	--	--	--	--	--	--	**4.1**	**3.2**	**30**
Oxychlordane	--	--	--	--	--	--	0.52 U	0.41 U	1.2 U
Toxaphene	0.1	--	5,000	5,000	10,000	0.42	*17 U*	*14 U*	*40 U*
Total DDx (U = 0)	7	4,450	1,000	1,000	--	--	**127.1 J**	**69.5**	**175.5**
Herbicides (μg/kg)									
2,4,5-TP (Silvex)	--	--	10,000	10,000	20,000	--	4.6 U	3.6 U	4.2 U
2,4-D (2,4-Dichlorophenoxyacetic acid)	--	--	100,000	100,000	200,000	--	28 U	22 U	26 U

Table C1
Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft
PCB Congeners - Low resolution (µg/kg)									
PCB-005/008	--	--	--	--	--	--	0.15 U	0.12 U	0.14 U
PCB-018	--	--	--	--	--	--	0.13 U	0.097 U	0.12 U
PCB-028	--	--	--	--	--	--	0.13 U	0.1 U	0.12 U
PCB-031	--	--	--	--	--	--	0.098 U	0.076 U	0.09 U
PCB-033	--	--	--	--	--	--	0.074 U	0.057 U	0.068 U
PCB-044	--	--	--	--	--	--	0.29 U	**1.9**	0.27 U
PCB-049	--	--	--	--	--	--	0.096 U	**1.3**	**0.93**
PCB-052	--	--	--	--	--	--	**1.6**	**3.5**	**2.7**
PCB-056	--	--	--	--	--	--	0.15 U	0.11 U	0.13 U
PCB-060	--	--	--	--	--	--	0.1 U	0.079 U	0.093 U
PCB-066	--	--	--	--	--	--	**1.2**	**1.6**	**0.82**
PCB-070	--	--	--	--	--	--	**1.3**	**3.5**	**2.1**
PCB-074	--	--	--	--	--	--	0.17 U	0.14 U	0.16 U
PCB-087	--	--	--	--	--	--	**2.1**	0.17 U	**3.1**
PCB-095	--	--	--	--	--	--	**2.3**	**6.5**	**4**
PCB-097	--	--	--	--	--	--	0.09 U	0.069 U	**1.9**
PCB-099	--	--	--	--	--	--	**1.9**	**4.4**	**2.4**
PCB-101	--	--	--	--	--	--	**3.6**	**11**	**6.1**
PCB-105	--	--	--	--	--	--	0.1 U	**6.2**	**2.3**
PCB-110	--	--	--	--	--	--	**4.3**	**30**	**6.7**
PCB-118	--	--	--	--	--	--	**3.6**	**34**	**4.4**
PCB-128	--	--	--	--	--	--	0.23 U	0.18 U	0.21 U
PCB-132/153	--	--	--	--	--	--	**4.9**	**13**	**6.9**
PCB-138/158	--	--	--	--	--	--	**4.7**	**13**	**7.5**

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	**PEL**	**TTLC**	**10 x STLC Screening Level**	**20 x TCLP Screening Level**	**Tier I Soil ESL**	**LT-01-021318 2/13/2018 0 - 14 ft**	**LT-02-021418 2/14/2018 0 - 9.9 ft**	**LT-03-021418 2/14/2018 0 - 10.3 ft**
PCB-149	--	--	--	--	--	--	**2.4**	**7.7**	**3.9**
PCB-151	--	--	--	--	--	--	0.17 U	**2.5**	0.16 U
PCB-156	--	--	--	--	--	--	0.15 U	0.12 U	0.14 U
PCB-170	--	--	--	--	--	--	0.22 U	**2.9**	**1.9**
PCB-174	--	--	--	--	--	--	0.081 U	0.063 U	0.074 U
PCB-177	--	--	--	--	--	--	0.23 U	0.18 U	0.21 U
PCB-180	--	--	--	--	--	--	**2.8**	**5.5**	**3**
PCB-183	--	--	--	--	--	--	**0.81**	**1.1**	**0.97**
PCB-187	--	--	--	--	--	--	**1.1**	**2.6**	**1.7**
PCB-194	--	--	--	--	--	--	0.14 U	0.11 U	0.13 U
PCB-195	--	--	--	--	--	--	0.12 U	0.09 U	0.11 U
PCB-201	--	--	--	--	--	--	0.066 U	0.051 U	0.06 U
PCB-203	--	--	--	--	--	--	0.11 U	0.087 U	0.1 U
Total PCB Congener - low resolution (U = 0)	34.1	277	50,000	50,000	--	--	**38.61**	**152.2**	**63.32**
Total Petroleum Hydrocarbons (mg/kg)									
Gas Range Organics (C4-C12)	--	--	--	--	--	100	0.46 U	0.35 U	0.43 U
Motor oil range hydrocarbons (C23-C44)	--	--	--	--	--	5100	**6.3 J**	**27**	**22**
Total petroleum hydrocarbons (C13-C22)	--	--	--	--	--	230	2.5 U	**3.8 J**	**3.2 J**

Notes:

All undetect results are reported at the method detection limit.

Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest detection limit is reported as the sum.

Total DDx is the sum of 4,4'-DDD, 4,4'-DDE, 4,4'-DDT 2,4'-DDD, 2,4'-DDE, and 2,4'-DDT, if measured.

Total HPAH (12 of 25) is the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(e)pyrene, benzo(b)fluoranthenes, benzo(k)fluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, perylene, and pyrene.

Total LPAH (13 of 25) is the sum of 1-methylnaphthalene, 1-methylphenanthrene, 1,6,7-trimethylnaphthalene, 2,6-dimethylnaphthalene, 2-methylnapthalene, acenaphthene, acenaphthylene, anthracene, biphenyl, dibenzothiophene, fluorene, naphthalene, and phenanthrene.

Table C1

Results of Physical and Chemical Analyses on Vertical Composite Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-021318 2/13/2018 0 - 14 ft	LT-02-021418 2/14/2018 0 - 9.9 ft	LT-03-021418 2/14/2018 0 - 10.3 ft

Total PCB congeners is the sum of all PCB congeners listed in this table.

USEPA Stage 1 data validation was completed by Anchor QEA.

Detected concentration is greater than one or more screening levels

Italicized : Non-detected concentration is above one or more identified screening levels

--: results not reported or not applicable

Bold: Detected result

µg/kg: micrograms per kilogram

ESL: Environmental Screening Level

ft: feet

HPAH: high molecular weight PAH

J: estimated value

LPAH: low molecular weight PAH

mg/kg: milligrams per kilogram

mm: millimeter

PAH: polycyclic aromatic hydrocarbons

PCB: polychlorinated biphenyls

pct: percent

PEL: Probable Effect Level

STLC: Soluble Threshold LimitCconcentration

TCLP: toxicity characteristic leaching procedure

TEL: Threshold Effect Level

TTLC: Total Threshold Limit Concentration

U: compound analyzed, but not detected above detection limit

Table C2

Results of Chemical Analysis on VOC Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-1.0-1.5-021318 2/13/2018 1 - 1.5 ft	LT-02-8.0-8.5-021418 2/14/2018 8 - 8.5 ft	LT-03-5.0-5.5-021418 2/14/2018 5 - 5.5 ft
Conventional Parameters (pct)									
Total solids	--	--	--	--	--	--	**37.2**	**65.6**	**51.4**
Volatile Organics (µg/kg)									
1,1,1,2-Tetrachloroethane	--	--	--	--	--	10	0.78 U	0.41 U	0.51 U
1,1,1-Trichloroethane	--	--	--	--	--	7,800	0.74 U	0.39 U	0.48 U
1,1,2,2-Tetrachloroethane	--	--	--	--	--	18	1.1 U	0.59 U	0.74 U
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	--	--	--	--	--	--	1.2 U	0.6 U	0.75 U
1,1,2-Trichloroethane	--	--	--	--	--	70	1.2 U	0.61 U	0.76 U
1,1-Dichloroethane	--	--	--	--	--	200	0.69 U	0.36 U	0.45 U
1,1-Dichloroethene	--	--	--	--	14,000	550	1.1 U	0.59 U	0.74 U
1,1-Dichloropropene	--	--	--	--	--	--	1.1 U	0.56 U	0.7 U
1,2,3-Trichlorobenzene	--	--	--	--	--	--	3 U	1.6 U	2 U
1,2,3-Trichloropropane	--	--	--	--	--	--	2.7 U	1.4 U	1.8 U
1,2,4-Trichlorobenzene	--	--	--	--	--	1,500	1 U	0.53 U	0.66 U
1,2,4-Trimethylbenzene	--	--	--	--	--	--	1.9 U	1 U	1.3 U
1,2-Dibromo-3-chloropropane	--	--	--	--	--	4.5	*5.7 U*	3 U	3.7 U
1,2-Dichlorobenzene	--	--	--	--	--	1,600	0.75 U	0.39 U	0.49 U
1,2-Dichloroethane	--	--	--	--	10,000	4.5	1 U	0.54 U	0.67 U
1,2-Dichloroethene, cis-	--	--	--	--	--	190	0.91 U	0.48 U	0.6 U
1,2-Dichloroethene, trans-	--	--	--	--	--	670	1.7 U	0.87 U	1.1 U
1,2-Dichloropropane	--	--	--	--	--	120	1.4 U	0.75 U	0.94 U
1,3,5-Trimethylbenzene (Mesitylene)	--	--	--	--	--	--	1.8 U	0.94 U	1.2 U
1,3-Dichlorobenzene	--	--	--	--	--	7,400	0.58 U	0.3 U	0.38 U
1,3-Dichloropropane	--	--	--	--	--	--	0.83 U	0.43 U	0.54 U

Table C2

Results of Chemical Analysis on VOC Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	**PEL**	**TTLC**	**10 x STLC Screening Level**	**20 x TCLP Screening Level**	**Tier I Soil ESL**	**LT-01-1.0-1.5-021318 2/13/2018 1 - 1.5 ft**	**LT-02-8.0-8.5-021418 2/14/2018 8 - 8.5 ft**	**LT-03-5.0-5.5-021418 2/14/2018 5 - 5.5 ft**
1,3-Dichloropropene, cis-	--	--	--	--	--	--	0.83 U	0.44 U	0.54 U
1,3-Dichloropropene, trans-	--	--	--	--	--	--	2 U	1 U	1.3 U
1,4-Dichlorobenzene	--	--	--	--	150,000	590	0.73 U	0.38 U	0.47 U
2,2-Dichloropropane	--	--	--	--	--	--	1.1 U	0.57 U	0.71 U
2-Chlorotoluene	--	--	--	--	--	--	0.76 U	0.4 U	0.49 U
2-Hexanone (Methyl butyl ketone)	--	--	--	--	--	--	5.8 U	3 U	3.8 U
4-Chlorotoluene	--	--	--	--	--	--	0.7 U	0.37 U	0.46 U
4-Methyl-2-pentanone (Methyl isobutyl ketone)	--	--	--	--	--	2,800	14 U	7.4 U	9.2 U
Acetone	--	--	--	--	--	500	**72 J**	**31 J**	**28 J**
Benzene	--	--	--	--	10,000	44	**0.43 J**	**0.32 J**	0.28 U
Bromobenzene	--	--	--	--	--	--	0.69 U	0.36 U	0.45 U
Bromochloromethane	--	--	--	--	--	--	2.3 U	1.2 U	1.5 U
Bromodichloromethane	--	--	--	--	--	520	0.76 U	0.4 U	0.5 U
Bromoform (Tribromomethane)	--	--	--	--	--	1,700	2.6 U	1.4 U	1.7 U
Bromomethane (Methyl bromide)	--	--	--	--	--	300	31 U	16 U	20 U
Carbon disulfide	--	--	--	--	--	--	**23 J**	**2.8 J**	**7.9 J**
Carbon tetrachloride (Tetrachloromethane)	--	--	--	--	10,000	48	0.92 U	0.49 U	0.6 U
Chlorobenzene	--	--	--	--	2,000,000	1,500	0.73 U	0.38 U	0.48 U
Chloroethane	--	--	--	--	--	1,100	4.9 U	2.6 U	3.2 U
Chloroform	--	--	--	--	120,000	68	0.78 U	0.41 U	0.51 U
Chloromethane	--	--	--	--	--	29,000	0.99 U	0.52 U	0.65 U
Cymene, p- (4-Isopropyltoluene)	--	--	--	--	--	--	2.1 U	1.1 U	1.3 U
Dibromochloromethane	--	--	--	--	--	3,800	1.9 U	0.98 U	1.2 U
Dibromomethane	--	--	--	--	--	--	2.5 U	1.3 U	1.7 U

Table C2
Results of Chemical Analysis on VOC Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-1.0-1.5-021318 2/13/2018 1 - 1.5 ft	LT-02-8.0-8.5-021418 2/14/2018 8 - 8.5 ft	LT-03-5.0-5.5-021418 2/14/2018 5 - 5.5 ft
Dichlorodifluoromethane	--	--	--	--	--	--	1.5 U	0.76 U	0.95 U
Dichloromethane (Methylene chloride)	--	--	--	--	--	77	4.4 U	2.3 U	2.9 U
Diisopropylether (Isopropyl Ether)	--	--	--	--	--	--	1.6 U	0.83 U	1 U
Ethanol	--	--	--	--	--	--	270 U	140 U	180 U
Ethyl tert-butyl ether (ETBE)	--	--	--	--	--	--	1.7 U	0.87 U	1.1 U
Ethylbenzene	--	--	--	--	--	1,400	0.5 U	0.26 U	0.32 U
Ethylene dibromide (1,2-Dibromoethane)	--	--	--	--	--	0.33	*0.84 U*	*0.44 U*	*0.55 U*
Isopropylbenzene (Cumene)	--	--	--	--	--	--	1.8 U	0.94 U	1.2 U
m,p-Xylene	--	--	--	--	--	--	0.88 U	0.46 U	0.57 U
Methyl ethyl ketone (2-Butanone)	--	--	--	--	4,000,000	5,100	12 U	6.5 U	8.1 U
Methyl tert-butyl ether (MTBE)	--	--	--	--	--	23	0.97 U	0.51 U	0.63 U
Naphthalene	34.6	391	--	--	--	33	2.7 U	1.4 U	1.7 U
n-Butylbenzene	--	--	--	--	--	--	0.51 U	0.27 U	0.33 U
n-Propylbenzene	--	--	--	--	--	--	1.6 U	0.86 U	1.1 U
o-Xylene	--	--	--	--	--	--	1.8 U	0.95 U	1.2 U
sec-Butylbenzene	--	--	--	--	--	--	1.9 U	0.99 U	1.2 U
Styrene	--	--	--	--	--	1,500	2 U	1 U	1.3 U
tert-Amyl methyl ether (TAME)	--	--	--	--	--	--	1.2 U	0.6 U	0.75 U
tert-Butyl alcohol (2-Methyl-2-propanol)	--	--	--	--	--	75	17 U	8.9 U	11 U
tert-Butylbenzene	--	--	--	--	--	--	0.49 U	0.26 U	0.32 U
Tetrachloroethene (PCE)	--	--	--	--	14,000	420	0.69 U	0.36 U	0.45 U
Toluene	--	--	--	--	--	2,900	1.7 U	0.88 U	1.1 U
Trichloroethene (TCE)	--	--	2,040,000	2,040,000	10,000	460	0.98 U	0.52 U	0.64 U

Table C2
Results of Chemical Analysis on VOC Samples from Lake Temescal

	Wetland		Landfill			Upland	Sample Results		
	TEL	PEL	TTLC	10 x STLC Screening Level	20 x TCLP Screening Level	Tier I Soil ESL	LT-01-1.0-1.5-021318 2/13/2018 1 - 1.5 ft	LT-02-8.0-8.5-021418 2/14/2018 8 - 8.5 ft	LT-03-5.0-5.5-021418 2/14/2018 5 - 5.5 ft
Trichlorofluoromethane (Fluorotrichloromethane)	--	--	--	--	--	--	1.2 U	0.64 U	0.8 U
Vinyl acetate	--	--	--	--	--	--	16 U	8.1 U	10 U
Vinyl chloride	--	--	--	--	4,000	8.2	1.6 U	0.86 U	1.1 U
Total BTEX (U = 0)	--	--	--	--	--	--	**0.43 J**	**0.32 J**	1.2 U
Total Xylene (U = 0)	--	--	--	--	--	--	1.8 U	0.95 U	1.2 U

Notes:
All undetect results are reported at the method detection limit.
Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest detection limit is reported as the sum.
USEPA Stage 1 data validation was completed by Anchor QEA.
--: results not reported or not applicable
Bold: Detected result
µg/kg: micrograms per kilogram
ESL: Environmental Screening Level
ft: feet
J: estimated value
pct: percent
PEL: Probable Effect Level
STLC: Soluble Threshold LimitCconcentration
TCLP: toxicity characteristic leaching procedure
TEL: Threshold Effect Level
U: compound analyzed, but not detected above detection limit

Attachment D

Laboratory Report

Appendix C
Hydraulic Residence Time and Nutrient Loading Calculations

Table C-1
Hydraulic Residence Time

Flow Rate (cubic feet per second)	Residence Time at 20,000 Square Feet and 1-Foot Depth (days)	Residence Time at 40,000 Square Feet and 1-Foot Depth (days)
5	0.05	0.09
3	0.08	0.15
1	0.23	0.46
0.15[a]	1.54	3.09
0.1[a]	2.31	4.63
0.08[a]	2.89	5.79

Notes:

Target hydraulic residence time in the treatment wetland is 2 to 7 days. Treatment wetland could initially be 1.5 to 2 feet deep. A depth of 1 foot used in calculations to ensure adequate hydraulic resident time in wetlands after they've accumulated sediment and organic matter.

b. Estimates of dry season flows in Temescal Creek range from 0.08 to 0.15 cubic foot per second (Bauer et al. 2006)

Table C-2
Nutrient Loading Calculations

Summer Flow (cfs)	Total Phosphorus[1] (µg/L)	Total Nitrogen[2] (mg/L)	Phosphorus Load per Year (g per year)	Nitrogen Load per Day (mg per day)	20,000 Square Feet Treatment (m^2)	40,000 Square Feet Treatment (m^2)	Summer Nitrogen Removal (mg per day)		Permanent Phosphorus Removal Without Fall/Winter Vegetation Removal (g per year)	
							20,000 square feet	40,000 square feet	20,000 square feet	40,000 square feet
0.08	210	2	15,004	391,496	1,858	3,716	1,486,400	2,972,800	1,858	3,716
0.15	210	2	28,133	734,054	1,858	3,716	1,486,400	2,972,800	1,858	3,716

Notes:
Denitrification rates can be 800 mg of nitrogen per m^2 per day in the summer and 200 mg during other parts of the year
Permanent phosphorus removal is 1 g per m^2 per year, better if vegetation harvested
Higher phosphorus removal during growing season, phosphorus released during winter (or harvested)

1. Sampling completed in summer 2016 showed total phosphorus concentrations of 176 to 243 µg/L at mouth of creeks.
2. 2 mg/L of nitrogen is higher than reported most months. Most nitrogen values were 0.0, with occasional measurements of 2 or 3 mg/L

µg: microgram
cfs: cubic feet per second
g: gram
L: liter
m^2: square meter
mg: milligram

Appendix D
Order-of-Magnitude Costs: Notes and Assumptions

Table D-1

Order-of-Magnitude Cost Details: Alternative 1, Hydraulic Dredge and Geotextile Tube Dewatering

Item No.	Description	Quantity	Units	Unit Cost	Total Cost	Comments
1	Mobilization/Demobilization	1	Lump Sum	$500,000	$500,000	Assume mobilization of 10-inch hydraulic dredge and support equipment; geotextile tube dewatering system and supporting water management equipment
2	Site Preparation (Upper and Lower Laydown Areas)	1	Lump Sum	$225,000	$225,000	Assumes effort to construct on-site staging areas for geotextile tubes in both north and south laydown areas; installation of water collection/management system for returning water to lake
3	Surveys	1	Lump Sum	$75,000	$75,000	Includes pre-construction, post-construction, and interim progress surveys. Owner to use contractor surveys for measurement/payment of work and no third-party quality assurance survey program will be required
4	Hydraulic Dredging	180,000	Cubic Yard	$18	$3,240,000	Assumes 8-inch or 10-inch cutterhead dredge will be used; inflow to lake from two stream inputs will provide sufficient water volume to manage dredge operations; additional input water will not be required; production rates to be approximately 300 cubic yards per day
5	Dewatering (Geotextile Tubes)	180,000	Cubic Yard	$15	$2,700,000	Geotextile tubes will be approximately 80 feet in circumference; length to be determined; tubes to be staged in upper and lower staging areas; assume approximately 1 month to fill and dewater tube
6	Wetland Material Placement	30,000	Cubic Yard	$6	$180,000	Assume reuse of dredged/dewatered sediment; material placement and grading completed using excavator and dozer; no in-water work required for placement of this material; no additional import material is required; costs for vegetation of the Caldecott and Temescal wetland areas not included

Item No.	Description	Quantity	Units	Unit Cost	Total Cost	Comments
7	Wetland Sediment Collection Area	5,000	Square Foot	$3	$15,000	Assumes effort to grade (excavator and dozer) the new wetland sediment collection area; effort to be completed as part of the wetland material placement activities and using similar equipment
8	On-Site Grading	30,000	Cubic Yard	$4	$120,000	Assume reuse of dredged/dewatered sediment; material placement and grading completed using excavator and dozer; no in-water work required for placement of this material; no additional import material is required
9	Excess Material Trucking	120,000	Cubic Yard	$8	$960,000	Material trucked to facility within 30 miles of Lake Temescal site for disposal (facility to be determined)
10	Excess Material Disposal	120,000	Cubic Yard	$56	$6,720,000	Assumed landfill tipping fee for local disposal
11	Sediment Basin Expansion (including sediment disposal at landfill)	Lump Sum	1	$300,000	$300,000	Assumed expansion occurs independently from dredging project; includes trucking and disposal fees
12	Oxygenation and Recirculation	Lump Sum	1	$100,000	$100,000	Placeholder for oxygenation system and/or recirculation piping
13	Site Restoration	1	Lump Sum	$1,000,000	$1,000,000	Assumes cost for repair of both site laydown areas and restoration to re-open park and facilities fully to the public, including re-paving parking areas and restoring concrete walkways
				Construction Subtotal	***$16,135,000***	
				Project Contingency (25%)	$4,034,000	
				Construction Total	**$20,169,000**	

Notes:
Project to be completed as one construction effort (i.e., one mobilization and one demobilization) over an approximate 20-month duration
Public access to Lake Temescal and parking/trail/field areas will be limited throughout duration of the project and may be completely restricted for periods of time
Project to be completed as one construction effort (i.e., one mobilization and one demobilization) over an approximate 20-month duration
Public access to Lake Temescal and parking/trail/field areas will be limited throughout duration of the project and may be completely restricted for periods of time
Work to be completed using one dredge working one shift per day (10-hour shift) and 7 days per week to develop the 300-cubic-yard per day production rate; production rates can be increased by working multiple shifts per day
Construction costs do not include debris removal effort (if required)
Dredged material and dredge water is considered clean for management and disposal purposes; dredge water does not require treatment prior to return discharge to Lake Temescal
Costs do not include effort for additional design data collection, planning/permitting, engineering design, bid support, and construction management support

Table D-2

Order-of-Magnitude Cost Details: Alternative 2, Hydraulic Dredge and Rapid Dewatering System

Item No.	Description	Quantity	Units	Unit Cost	Total Cost	Comments
1	Mobilization/ Demobilization	1	Lump Sum	$650,000	$650,000	Assume mobilization of 10-inch hydraulic dredge and support equipment; RDS equipment and supporting water management equipment
2	Site Preparation (Upper and Lower Laydown Areas)	1	Lump Sum	$175,000	$175,000	Assumes effort to construct on-site staging areas for the RDS (lower laydown area); installation of water collection/management system for returning water to lake
3	Surveys	1	Lump Sum	$75,000	$75,000	Includes pre-construction, post-construction, and interim progress surveys. Owner to use contractor surveys for measurement/payment of work and no third-party quality assurance survey program will be required
4	Hydraulic Dredging	180,000	Cubic Yard	$18	$3,240,000	Assumes 8-inch or 10-inch cutterhead dredge will be used; inflow to lake from two stream inputs will provide sufficient water volume to manage dredge operations; additional input water will not be required; production rates to be approximately 300 cubic yards per day
5	Dewatering (Rapid Dewatering System)	180,000	Cubic Yard	$30	$5,400,000	Dredged material and water will be processed through an RDS constructed in the lower laydown area; processed dredge water will be collected and gravity drained for discharge to Lake Temescal
6	Wetland Material Placement	30,000	Cubic Yard	$6	$180,000	Assume reuse of dredged/dewatered sediment; material placement and grading completed using excavator and dozer; no in-water work required for placement of this material; no additional import material is required; costs for vegetation of the Caldecott and Temescal wetland areas not included
7	Wetland Sediment Collection Area	5,000	Square Foot	$3	$15,000	Assumes effort to grade (excavator and dozer) the new wetland sediment collection area; effort to be completed as part of the wetland material placement activities and using similar equipment

Item No.	Description	Quantity	Units	Unit Cost	Total Cost	Comments
8	On-Site Grading	30,000	Cubic Yard	$4	$120,000	Assume reuse of dredged/dewatered sediment; material placement and grading completed using excavator and dozer; no in-water work required for placement of this material; no additional import material is required
9	Excess Material Trucking	130,000	Cubic Yard	$8	$960,000	Material trucked to facility within 30 miles of Lake Temescal site for disposal (facility to be determined)
10	Excess Material Disposal	130,000	Cubic Yard	$56	$6,720,000	Assumed landfill tipping fee for local disposal
11	Sediment Basin Expansion (including sediment disposal at landfill)	Lump Sum	1	$300,000	$300,000	Assumed expansion occurs independently from dredging project; includes trucking and disposal fees
12	Oxygenation and Recirculation	Lump Sum	1	$100,000	$100,000	Placeholder for oxygenation system and/or recirculation piping
13	Site Restoration	1	Lump Sum	$150,000	$150,000	Assumes cost for repair of one site laydown area and restoration to re-open park and facilities fully to the public; assumes minimal to no impact to parking pavement
				Construction Subtotal	***$18,085,000***	
				Project Contingency (25%)	$4,522,000	
				Construction Total	**$22,607,000**	

Notes:
Project to be completed as one construction effort (i.e., one mobilization and one demobilization) over an approximate 20-month duration
Public access to Lake Temescal and parking/trail/field areas will be limited throughout duration of the project and may be completely restricted for periods of time
Work to be completed using one dredge working one shift per day (10-hour shift) and 7 days per week to develop the 300-cubic-yard per day production rate; production rates can be increased by working multiple shifts per day
Construction costs do not include debris removal effort (if required)
Dredged material and dredge water is considered clean for management and disposal purposes; dredge water does not require treatment prior to return discharge to Lake Temescal
Costs do not include effort for additional design data collection, planning/permitting, engineering design, bid support and construction management support

Table D-3

Order-of-Magnitude Cost Details: Alternative 3, Mechanical Dredge and Working and Disking

Item No.	Description	Quantity	Units	Unit Cost	Total Cost	Comments
1	Mobilization/Demobilization	1	Lump Sum	$200,000	$200,000	Assume mobilization of barge mounted excavator and support equipment; Offloading operation; Dewatering land-based equipment
2	Site Preparation (Lower Laydown Areas)	1	Lump Sum	$175,000	$175,000	Assumes effort to construct on-site staging areas dewatering (lower laydown area); installation of water collection/management system for returning water to lake
3	Surveys	1	Lump Sum	$75,000	$75,000	Includes pre-construction, post-construction, and interim progress surveys. Owner to use contractor surveys for measurement/payment of work and no third-party quality assurance survey program will be required
4	Mechanical Dredging	180,000	Cubic Yard	$50	$9,000,000	Assumes mechanical dredge will be used; 1- to 1.5-cubic-yard bucket; Offloading facility to unload scows; two scows in rotation approximately 50 cubic yards each; dredge production rates to be approximately 200 cubic yards per day
5	Dewatering (Working/Disking)	180,000	Cubic Yard	$10	$1,800,000	Dredged material and water will be processed through working and disking using land-based equipment at the lower laydown area; processed dredge water will be collected and gravity drained for discharge to Lake Temescal
6	Wetland Material Placement	30,000	Square Foot	$6	$180,000	Assumes effort to grade (excavator and dozer) the new wetland sediment collection area; effort to be completed as part of the wetland material placement activities and using similar equipment
7	Wetland Sediment Collection Area	5,000	Cubic Yard	$3	$15,000	Assume reuse of dredged/dewatered sediment; material placement and grading completed using excavator and dozer; no in-water work required for placement of this material; no additional import material is required; costs for vegetation of the Caldecott and Temescal wetland areas not included

Item No.	Description	Quantity	Units	Unit Cost	Total Cost	Comments
8	On-Site Grading	30,000	Cubic Yard	$4	$120,000	Assume reuse of dredged/dewatered sediment; material placement and grading completed using excavator and dozer; no in-water work required for placement of this material; no additional import material is required
9	Excess Material Trucking	120,000	Cubic Yard	$8	$960,000	Material trucked to facility within 30 miles of Lake Temescal site for disposal (facility to be determined)
10	Excess Material Disposal (Ox Mountain)	120,000	Cubic Yard	$56	$6,720,000	Assumed landfill tipping fee for local disposal
11	Sediment Basin Expansion (including sediment disposal at landfill)	Lump Sum	1	$300,000	$300,000	Assumed expansion occurs independently from dredging project; includes trucking and disposal fees
12	Oxygenation and Recirculation	Lump Sum	1	$100,000	$100,000	Placeholder for oxygenation system and/or recirculation piping
11	Site Restoration	1	Lump Sum	$150,000	$150,000	Assumes cost for repair of one site laydown area and restoration to re-open park and facilities fully to the public; assumes minimal to no impact to parking pavement
				Subtotal	***$19,795,000***	
				Contingency (25%)	$4,949,000	
				Construction Total	**$24,744,000**	

Notes:

Project to be completed as one construction effort (i.e., one mobilization and one demobilization) over an approximate 30-month duration

Public access to Lake Temescal and parking/trail/field areas will be limited throughout duration of the project and may be completely restricted for periods of time

Work to be completed using one dredge working one shift per day (10-hour shift) and 7 days per week to develop the 200-cubic-yard per day production rate; production rates can be increased by working multiple shifts per day

Construction costs do not include debris removal effort (if required)

Dredged material and dredge water is considered clean for management and disposal purposes; dredge water does not require treatment prior to return discharge to Lake Temescal

Costs do not include effort for additional design data collection, planning/permitting, engineering design, bid support and construction management support

Table D-4

Order-of-Magnitude Cost Details: Reporting, Regulatory, Design, and Construction Support

Item No.	Activity	Estimated Cost	Comments
Pre-Construction			
1	Sediment Characterization	$250,000	Assume sampling with a drilling rig to obtain depth; 12 to 16 cores individually tested in three segments each, tested for treatment wetland, upland reuse, and landfill criteria, including leachate; includes Z-layer testing; includes contingency for retesting of some constituents of concern; Assume standard laboratory turn-around time
2	Geotechnical Evaluations	$200,000	Allowance for geotechnical investigation of lake sediment to assess strength and setline properties; assume cores collected during sediment characterization effort
2	Environmental and Technical Studies	$150,000	Assume studies include wetland delineation, habitat assessments for listed or sensitive species, and cultural resources studies
3	California Environmental Quality Act	$750,000	Assume an EIR will be required to satisfy CEQA requirements
4	Permit Applications and Associated Reports	$150,000	Assume permit applications will be submitted to the U.S. Army Corps of Engineers, Regional Water Quality Control Board, and California Department of Fish and Wildlife. A Biological Assessment would also be prepared
5	Post-Application Agency Coordination	$75,000	Assume includes responses to meetings and application questions, comment, and requests for supplemental information
6	Engineering Design and Bid Support Services	$350,000	Assume engineering design includes preparation of bid documents at 30%, 60%, 90%, and 100% completion, as well as bid support
Construction and Post-Construction			
7	Construction Support Services	$690,000	Assume on-site observations up to three times a week during a project duration of 20 weeks with associated construction progress and contract compliance monitoring
8	Construction Environmental Compliance and Testing	$50,000	Assume compliance and testing includes on-site monitoring and testing during sediment dewatering and contingency for special-status species monitoring
	Total	**$2,665,000**	

Appendix E
Geotechnical Evaluation

A California Corporation
Specializing in Geotechnical Engineering

Hultgren-Tillis Engineers

January 3, 2019
Project No. 897.01

ANCHOR QEA, LLC
130 Battery Street, Suite 400
San Francisco, California 94111

Attention: Ms. Jaclyn Gnusti

Geotechnical Evaluation
Dredging Feasibility Study
Lake Temescal Dam
Oakland, California

Dear Ms. Gnusti:

This letter presents our geotechnical evaluation for the Lake Temescal Dredge Feasibility Study in Oakland, California. Lake Temescal dam and reservoir is owned and operated by East Bay Regional Park District (EBRPD). EBRPD proposes to improve water quality, dredge sediments, and restore Lake Temescal to historic conditions. Our scope consists of assessing potential impacts to dam safety due to dredge sediment removal. Our assessment is based on existing available data. A list of the references we reviewed are attached. No new subsurface exploration was performed for our assessment. Our goal is to assess the extent of sediment removal that could occur (a) without impacting the reliability of the dam and (b) without triggering State Division of Safety of Dams (DSOD) to ask for further analysis.

BACKGROUND AND AVAILABLE DATA

Lake Temescal dam is an earth-fill embankment constructed in 1869 along Temescal Creek. Based on DSOD Dam Statistics Summary Information, the dam is 116 feet tall, has a 650 foot long embankment with a crest width of 40 feet at approximate Elevation 439 feet based on the North American Vertical Datum of 1988 (NAVD88[1]).

EBRPD developed plans and specifications to raise and widen the dam crest in 1937. Other improvements included concrete facing along the upstream slope of the dam. The drawings indicate that the original dam crest width was initially 17 feet wide with side slopes inclined 2H:1V (horizontal to vertical). The proposed new crest fill (post 1937) included raising the crest up to 6 feet and widening the crest to 40 feet with upstream and downstream slopes inclined 2H:1V and 1.5H:1V, respectively.

[1] NAVD88 datum is about 2.8 feet below the NGVD29 datum. For example, Elevation 436 feet NGVD29 datum would convert to Elevation 438.8 feet based on NAVD88 datum. For purposes of this letter, we have rounded elevations to the nearest whole foot so as to not over represent the precision of the information. Unless noted otherwise, elevations discussed in this letter are based on the NAVD88 datum.

The dam was widened again and improvements to Highway 24 were performed in the 1960s. The dam increased to widths to its present day geometry ranging from 670 to 970 feet from upstream toe to downstream toe.

Survey data performed in 1907 indicate that the surface of lakebed sediments were near Elevation 393 feet. The data indicates that the sediment thickness at the time ranged from 30 to 40 feet thick in the northern portion of the lake near the dam.

In 1978, EBRPD developed plans to restore Lake Temescal and dredge lakebed sediments. Record drawings indicate that lakebed sediments were near Elevation 409 feet in the north part of the lake. The planned depth of dredge sediment excavation ranged from 6 to 8 feet. The drawing indicated that dredge sediment excavation was not planned within 100 feet of the dam. A post dredge survey performed in 1979 suggests that dredge sediment excavations were not performed in the north part of the lake and were only performed in the southern portion of the lake.

Bathymetric survey data performed in 2017 indicate that the lakebed sediments in the north portion of the dam are near Elevation 410 feet.

The most recent DSOD periodic inspection report of the dam and reservoir provided to us was performed in 2017. The report indicated that the broad crest and visual portions of the upstream slope appear to be satisfactory with no signs of slope instability and the downstream slope is not distinguishable.

DISCUSSION AND CONCLUSIONS

The conceptual project plans indicate dredging lakebed sediments to Elevation 391.6 feet. This elevation corresponds to an excavation depth of about 18 feet below existing grade beneath the northern portion of the lake.

The lakebed sediments consists of very soft, weak, plastic clays and silts with high water contents and low densities. These sediments are likely providing a small, increased buttressing benefit to the upstream face of Lake Temescal Dam. Previous geotechnical assessments by Woodward Clyde Consultants in 1978 recommended maintaining a dredge set back distance of 100 feet from the dam. We believe that was a reasonable criterion for avoiding further, more detailed geotechnical evaluations. We recommend that this same setback guideline be applied to the upcoming dredging episode. We judge that dredging sediments to depths of about 18 feet below existing grade at a setback of 100 feet will have no adverse impacts to dam safety.

We are not aware of any existing engineering evaluations of the dam including slope stability analyses, seepage analyses, seismic performance and deformation analyses, and fault offset impacts. If these evaluations exist, we should be contacted to review any sediment loading assumptions used in the analyses and whether any of the analyses relied upon the presence of the existing sediment that is being considered for removal.

CLOSURE

We trust this provides you with the information you require at this time. Should you have any questions or comments, please give us a call.

Sincerely,

Hultgren – Tillis Engineers

Callan J. Yu
Geotechnical Engineer

Edwin M. Hultgren
Geotechnical Engineer

CJY:EMH:lm:la

Attachment: References

Filename: 89701L01.docx

REFERENCES

Division of Safety of Dams. DSOD Dam Statistics Summary Information. Temescal, Lake Dam, No. 29.000, Area 2, Alameda County. Inspection dated March 22, 2017. Report dated March 29, 2017.

Division of Safety of Dams. Inspection of Dam and Reservoir in Certified Status. Lake Temescal, Dam No. 29-000, Alameda County. Printed: Tuesday, July 14, 2015, by: Tatyosian, John.

East Bay Regional Park District. Site Plan ADA Trail and Lighting, Sheet No. TS-1. April 1, 2009.

Ed. K. Hussey Engineering Corporation. Specifications for Repairing Temescal Dam, Oakland, Alameda County, California. The Property of East Bay Regional Park District, dated September 24, 1937. (DSOD File 251.1, Item #2).

eTrac, Inc. Lake Temescal Multibeam Survey, dated January 12, 2018.

GEI Consultants, Inc. Lake Temescal Dam Inundation Technical Study, State Dam No. 29.000, National Dam No. CA00160, dated September 17, 2018.

Peoples Water Company, Department of Sanitation. Topographic Map and Profile of Present Reservoir Bed as Determined by Surveys and Soundings, Temescal Reservoir, November 1907.

Towill Inc. Engineers & Surveyors San Francisco. Hydrographic Survey of Lake Temescal, Oakland, California, For: East Bay Regional Parks, Post Dredge Survey, dated June 18, 1979.

Wilsey & Ham. East Bay Regional Park District, Lake Temescal Restoration, Dredging and By-Pass Pipeline Plan, Oakland, California, Drawing No. 2 of 8, dated June 1978.

Woodward-Clyde Consultants. Geotechnical Engineering Studies, Lake Temescal Restoration, Oakland, California, August 22, 1978.

Woodward-Clyde Consultants. Preliminary Subsurface Exploration, Lake Temescal and Proposed Disposal Area, Oakland, California, December 14, 1977.

Appendix F
Historic Information and Reference Materials

Author / Source	Date	Document Type	Document	Notes
Peoples Water Company (Department of Sanitation)	1907 November	Survey	Topographic Map and Profile of Present Reservoir Bed (Temescal Reservoir)	Survey of the lake, including cross sections.
Edw. K. Hussey Engineering Corporation	1937 August 26	Design Plan	Plan, Profile and Cross-Sections of Temescal Dam	Design plans to raise the crest of the dam.
East Bay Regional Park District	1978	Report	Lake Temescal Restoration Draft Environmental Report (DEIR)	Report to modify the project description submitted in a 1976 DEIR after soils analysis determined an in-water dike would be problematic.
Koretsky King Associates	1978 January	Design Plan	Lake Temescal Restoration Proposed Project	Dredging plan and profile for proposed restoration project.
Wilsey & Ham	1978 June	Design Plan	Lake Temescal Restoration Dredging and By-Pass Pipeline Plan	Dredging plan and profile and section for proposed restoration project, including by-pass line.
Towill Inc.	1979 June 18	Survey	Hydrographic Survey of Lake Temescal - Post-Dredge Survey	Survey of the lake after dredging.
Environmental Protection Agency	1980 July	Report	Restoration of Lake Temescal - Capsule Report	Describes status of the lake and restoration methods, both historical and present (at the time).
East Bay Regional Park District	1992 May 1	Report (excerpts)	Temescal Recreation Area, Resource Analysis (Administrative Draft)	Excerpts, including 1991 Oakland fire impacts
East Bay Regional Park District	1993	Report (excerpts)	Temescal Regional Recreation Area, land Use-Development Plan and Draft Environmental Impact Report	Excerpts regarding history of the lake and hydrology and water quality.
Booker et al	1993 November/ December	Article	Runoff and Erosion after the Oakland Firestorm, Expectations and Observations	Research article in November/December 1993 edition of California Geology.
City of Oakland	1996 June	Report (Executive Summary)	City of Oakland Open Space Conservation and Recreation (OSCAR)	An element of the Oakland General Plan
Figuers, S.	1998 June 15	Report	Groundwater Study and Water Supply History of the East Bay Plain, Alameda and Contra Costa Counties, CA	Prepared for Friends of the San Francisco Estuary by Norfleet Consultants
Friends of Temescal Creek	2002 through 2006	Data	WQ_Data_From_FOTC (file name)	Monitoring data from inlet at Lake Temescal

Author / Source	Date	Document Type	Document	Notes
Bauer et al	2006 "Fall"	Report	Temescal Creek, East Bay, CA: Assessment, Modifications, and Restoration	Student report for course Geography 642 Watershed Assessment and Restoration at San Francisco State University.
Bauer, J.	2007 "Spring"	Report	Geomorphic Responses to Urbanization Along Temescal Creek (It's All Creek to Me)	Student report for course Geography 810 Geomorphology at San Francisco State University.
U.S. Geological Survey	2007	Report	Multiple Landslide-Hazard Scenarios Modeled for the Oakland-Berkeley Area, Northern California	Scientific Investigations Report 2007-5196
Lewicki and McKee (SFEI)	2009 December	Report	Watershed Specific and Regional Scale Suspended Sediment Load Estimates for Bay Area Small Tributaries	SFEI Contribution #566. A technical report for the Sources Pathways and Loading Workgroup of the Regional Monitoring Program for Water Quality.
SePRO Research & Technology Campus	2016 August 9	Data	Laboratory Report	Laboratory data
Lovelace, F.	2017 March	Report	Sources of Excess Phosphate Leading to Cyanobacteria Blooms at Lake Temescal, Oakland, CA	A University Thesis presented to the faculty of California State University, East Bay.
Curtis & Tompkins, Ltd.	2007, 2008, 2009	Data	Soil testing data	Laboratory data
Curtis & Tompkins, Ltd.	2011, 2011, 2013, 2014, 2015, 2016	Data	Soil testing data	Laboratory data
IEH Analytical Laboratories	2017 August 15	Data	Final report, laboratory analysis of selected parameters on sediment samples from East Bay Regional Park District	Phosphorus testing from 6 stations in or near Lake Temescal.
Enthalpy Analytical	2017 September 22	Data	Soil testing data	Laboratory data
East Bay Regional Park District	2017 & 2018	Data	Water and nutrient monitoring data	Spreadsheet
eTrac	2018 January	Survey	Lake Temescal Multibeam Survey	Condition survey of lake and some upland points around the park; file include photographs
Anchor QEA	2018 June 21	Memorandum	Lake Temescal Exploratory Sediment Sampling and Analysis Report	Chemical testing results from 3 cores throughout the lake to provide general suitability indications for wetland, upland, and landfill placement or disposal.

Author / Source	Date	Document Type	Document	Notes
StreamStats	2018 July 05	Data	Report for Lake Temescal Watershed	Watershed data report including perimeter, slope, area, precipitation, and other information.
StreamStats	2018 October 22	Data	Report for Caldecott Watershed	Watershed data report - little to no data available.
Newspaper Articles	various	Articles		Obtained from public library.